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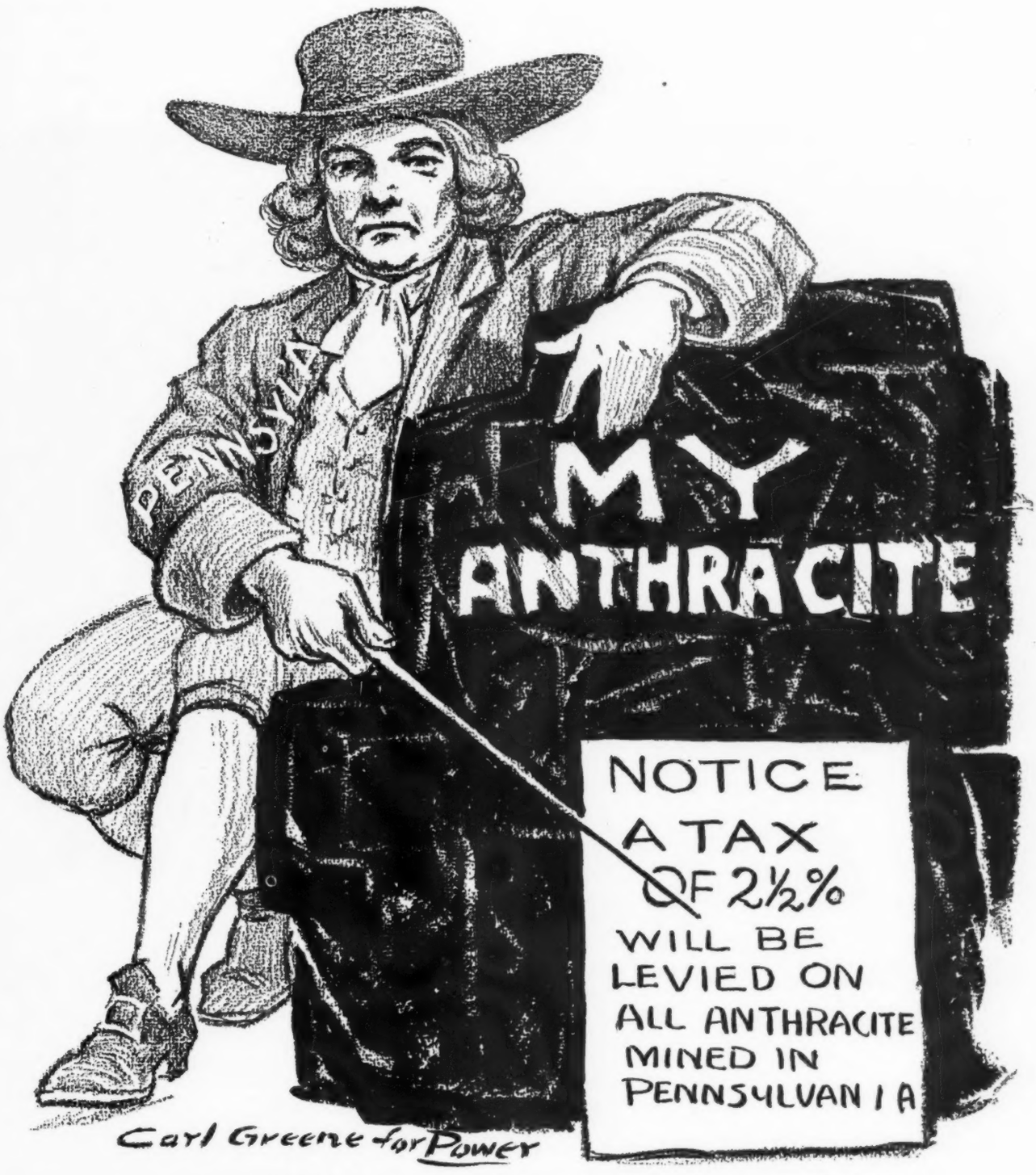


IS THIS BENIGN OLD GENTLEMAN TURNING INTO A SHYLOCK?

Butler Mill Mixed-Pressure Steam Turbine

By Warren O. Rogers

SYNOPSIS—Due to the installation of a mixed-pressure turbine, one 1250-kw. engine-driven generating unit has been shut down and the number of boilers under steam decreased. The turbine and one reciprocating unit generate an electrical output approximately equal to that of the two 1250-hp. reciprocating units.

If a visitor to the power plant of the Butler Mill, New Bedford, Mass., should mention mixed-pressure steam turbines to Thomas Quinn, chief engineer, an enthusiastic interest would at once be manifested. And with reason, because of the satisfactory results that have been obtained from such a unit in this mill power plant.

The original units in this plant consisted of two 21 and 52 by 42-in. vertical, cross-compound engines, with a speed of 133 r.p.m. Each unit is directly connected to a 1250-kw., alternating-current generator, delivering three-phase, 40-cycle electrical energy to the mill motors. Ten vertical boilers supplied steam to the engines, at 165 lb. pressure. Because of the much stricter structural requirements of the recently enacted state boiler laws, the boiler pressure was reduced to 140 lb., which is now carried. With this reduction it was necessary to operate 10 boilers. The growing power requirements of the mill made the load so heavy at peak loads that it was difficult to keep up the desired steam pressure, and consequently, the speed of the engines was occasionally reduced. This, for a few moments, made a decrease in the output of the mill products. In addition, the management desired more power to provide for increased loads on the power plant when contemplated changes were made.

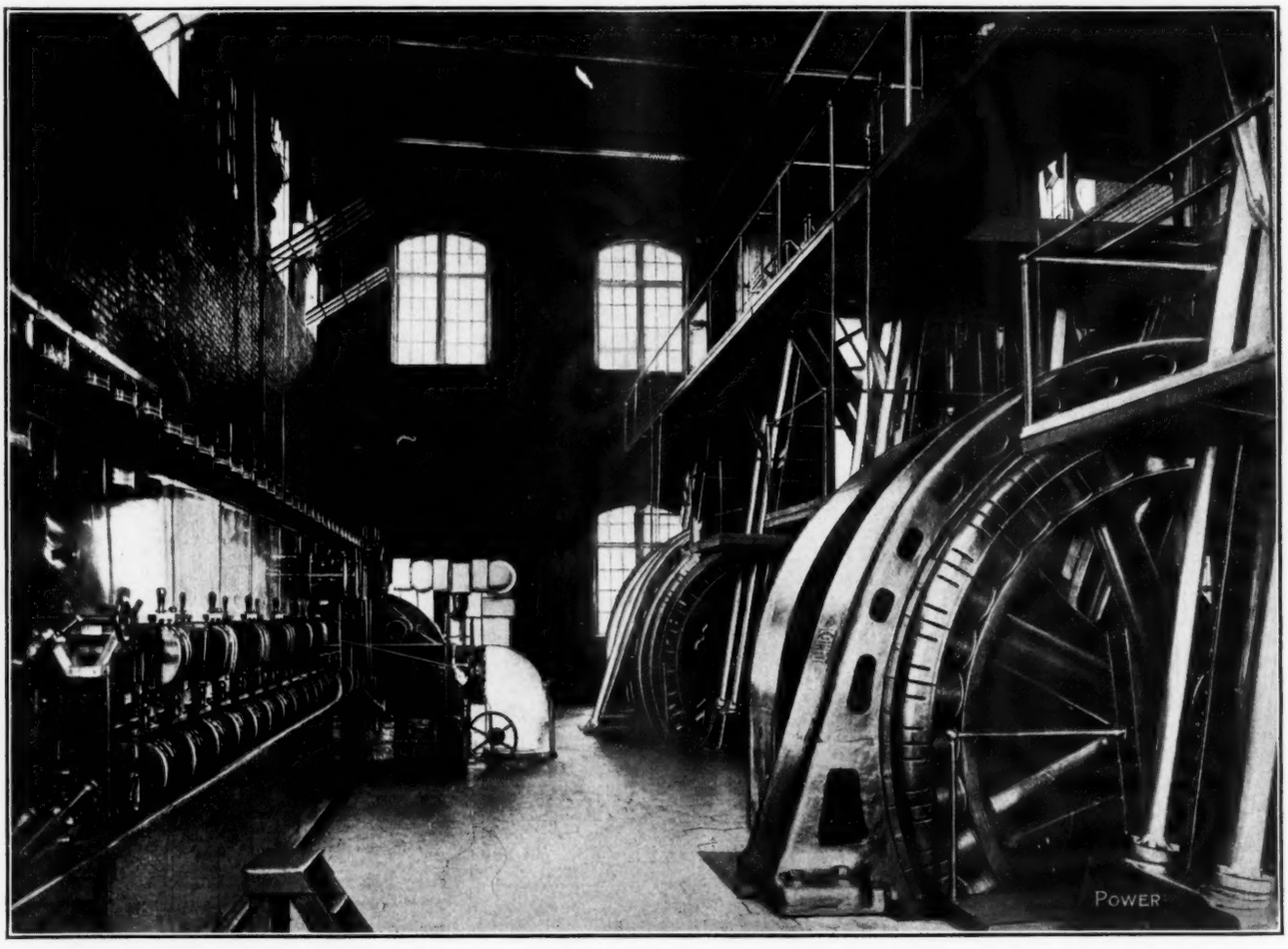


Fig. 1. Engine Room, Showing the 1250-Kw. Mixed-Pressure Turbine and the Two 1250-Hp. Reciprocating Units, One of Which Has Been Shut Down

It was at first planned to put in additional boilers, but after investigation the management decided to install a 1250-kw. Curtis mixed-pressure turbine and use the exhaust steam from one of the reciprocating units, Fig. 1. The turbine is designed to operate condensing on steam at from 16 to 165 lb., absolute. The turbine exhausts to a Bulkley injector condenser, Fig. 2, at from 28 to 29 in. vacuum, and is directly connected to a 1250-kw., 600-volt, three-phase, 40-cycle generator, Fig. 3. The generator of the turbine and that of the reciprocating engine are operated in parallel.

The reciprocating engines were connected to barometric condensers. One condenser was discarded with the installation of the turbine, but the other engine and condenser, which are shut down, can be used if the power demand exceeds the capacity of the engine-turbine units.

Another alteration was that of changing the ratio of the engine cylinders from 21 and 52 to 24 and 42 in., the stroke of 42 in. remaining the same. This was done by putting on a new high-pressure and bushing the low-pressure cylinder.

The reciprocating boiler-feed pumps were replaced by a turbine-driven centrifugal pump, the water going to the boilers at 212 deg. F. The water for the injector condenser is delivered by a turbine-driven centrifugal pump. The exhaust steam from these auxiliary turbines is used for heating the boiler-feed water, but, if desired, the exhaust steam can be sent to the turbine. Salt water from the harbor is used in the condenser. The

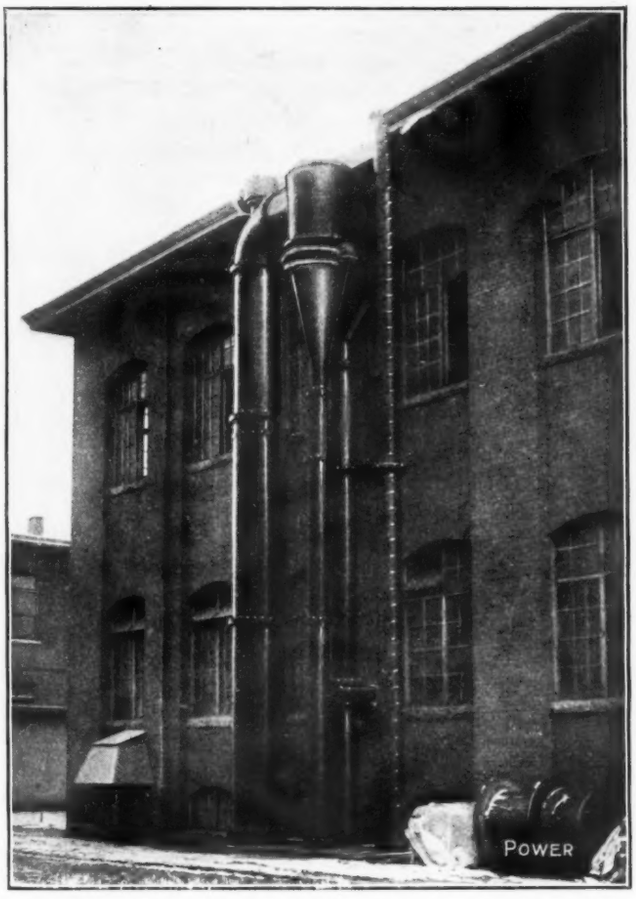


FIG. 2. INJECTION CONDENSER USED WITH MIXED-PRESSURE TURBINE

condenser injection-water pump has a capacity of 4000 gal. per min. against a 42-ft. head running at 1150 r.p.m.

Before making these changes it was figured that by so doing the necessity of installing additional boilers, another engine and a generator, and the condensing equipment would be eliminated; that some of the original boilers could be cut out of service, and these expectations have been realized.

At the time of the writer's visit to the plant, one of the engines was shut down. There were eight boilers under steam, although during the summer months six boilers will generate sufficient steam for the reciprocating and turbine units. The two extra boilers are necessary in heating the mill. In case the reciprocating engine should break down, the turbine can be operated on high-pressure steam and the idle engine can be operated as formerly.

The installation and operation of the mixed-pressure turbine and shutting down one engine have resulted in

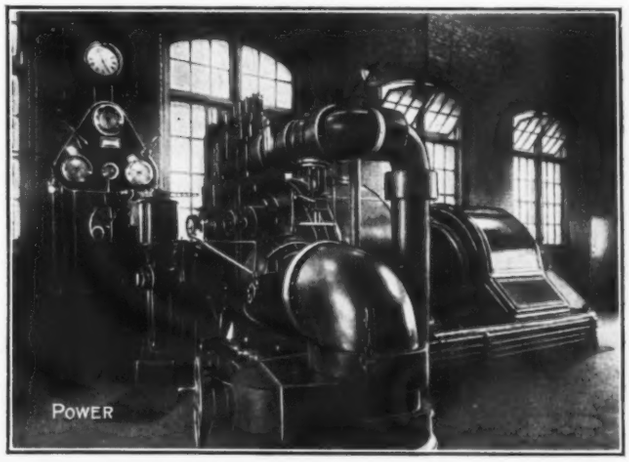


FIG. 3. COMPACT 1250-KW. MIXED-PRESSURE TURBINE

saving fuel, especially during the summer months, when four of the ten boilers are cut out of service. The boiler-room labor and the cost of lubricating the idle engine are also decreased. Under the old conditions, it was necessary to operate the boilers under induced draft, and then there was difficulty in keeping up steam; now they run under natural-draft conditions, with a reduction in the number of boilers and at a lower steam pressure.

The output of the two reciprocating engines, with full load, was approximately 2500 kw., with a normal load of about 975 kw. each. The load at the switchboard on the one engine and generator was 975 kw., the day of the writer's visit, and the turbine unit, using steam that had already developed this electrical output, was generating 925 kw., a load almost equal to that on the engine unit.

The success of this turbine-and-engine combination will be watched with interest by other mill men of New Bedford, as the Butler mill plant is the first and only one in the city in which a low-pressure turbine has been installed.

Some Mechanical Kinks to Prevent Clinkering

Where a coal clinkers badly on account of the sand and the bases being nearly balanced, the fusing point of these impurities can be raised by adding some more bases. Hence, to hinder the clinkers forming or prevent it entirely, add some limestone, magnesia rock or oyster shells, to the fire. Numerous schemes have been tried by firemen and engineers to prevent clinkers and considerable improvement has been made in late years in burning coal in boiler furnaces, especially in the use of the finer sizes and the refuse coals, or culms as they are sometimes called. Engineers who are giving special study to the problem of coal burning believe that further improvement is possible. Some of the refuse coals contain a great deal of sand, clay and iron, and clinker badly if burned in the old way.

One of the first clinker preventives tried on this class of fuel is the steam blower. This was used because it was easy to apply and "it does the work." Its virtue lies in its cooling action on the fire bed, for with some coals the higher the temperature of the fuel bed the greater the tendency to clinker. There is also a chemical action when water vapor passes over red-hot carbon. It must be remembered, however, that water is not a fuel, and for this reason many of the engineers who have advanced ideas on coal burning have insisted on the development of some other method both for making draft and for clinker prevention. In this they have been quite successful by using a special method of starting and cleaning the fires and by using a small air space and a high-pressure air blast. In starting the fire, plenty of kindling is used so as to make an evenly distributed fire and one that is brought up slowly. An ash bed is formed and kept over the entire grate.

If any clinkers form, even if very small ones, they should be removed when first cleaning the fire, as these little clinkers shield small areas of the fuel from the air blast and the clinker will continue to grow. The air distribution must be uniform. As to the air space in the grate, the old theory was to use a grate having the maximum air space which would at the same time prevent the fuel from falling through. This requires a relatively low draft pressure. The new plan is to reduce the air space, as much as 50 per cent. in some types of furnace, and to increase the blast. The effect where properly installed and operated has been remarkable. The high velocity of the blast through $\frac{1}{16}$-in. holes with 3-in. blast, and with a Dutch-oven furnace produces an intense furnace temperature. Under these conditions it is possible to keep a white heat in the furnace and at the same time have the grates free of clinker, and this, too, when burning a refuse coal that clinkers very badly if burned in the ordinary manner.

The size of the holes in the grates has a great deal to do with clinker formation. This applies both to the steam jet and to the air blast. A case is on record where four boilers of the locomotive type were fired by the same men and with the same coal, yet three of the furnaces clinkered badly and one did not. Steam jets were used in the ashpits. The difference lay in the grates. The three furnaces had $\frac{3}{16}$-in. holes, and the fourth one had $\frac{1}{8}$-in. holes. The latter, therefore, had been given more steam to obtain the desired rate of combustion, and had an air blast been used, it is likely that the grates having the smaller holes would have proved the better for preventing clinkers, because a stronger blast could have been used than would have been allowable with the larger grate openings.

Economical Burning of Fuel*

SYNOPSIS—Some practical points tending toward economy in the burning of oil, lignite and slack coal under boilers.

Oil Fuel

With fuel oil, which is high in carbon and quick to burn, the requirements are plenty of air at as near atmospheric pressure as possible; a thorough atomization, using as little steam as is necessary for the purpose, and just sufficient draft to pull the gases out through the boiler at the proper velocity, never over 0.10 in. of water in the uptake and less in the furnace. Have a large combustion chamber with no bridge-wall to retard the gas flow.

To control the draft it is necessary to use a damper in the uptake. Consider first that on full load there is a draft of 0.10 in. If the load drops, then the damper should be closed accordingly. The serious drawback to the common method of firing with oil is that a heavy draft is maintained on the entire furnace setting, causing an infiltration of cold air which dilutes the gases and reduces their temperature. These conditions prevail where the ashpit doors are used to control the air supply. These doors should be taken off when burning fuel oil.

When several boilers are under steam at a time, each one should be equipped with a draft gage, located in the uptake just below the damper; the dampers should be manipulated so that each gage registers the same draft pressure. This insures a uniform load for each boiler, provided that the furnaces are equally fired.

The approved type of oil burner spreads the oil fuel in a fan-like spray over the grates, which have been paved with firebrick arranged so that openings of about ½ to ¾ in. are left between them. The edge of the spray should come just to the side walls, so as to fill the combustion space with a well mixed and nonstratified gas. Always use a burner of sufficient size to fill the full width of the boiler setting and never try to operate one side at a time; use both or all burners, but reduce the capacity by the needle valve when full capacity is not required. Leave a clear space of 1 in. or more between the side walls and the grate pavement, thus permitting cold air to enter and prevent burning out the side walls. The use of target walls is not advisable.

The average fuel oil, as sold in Texas, has 18,600 B.t.u. per lb., the average steam pressure is 125 lb. and the feed-water temperature 208 deg. F. Under these conditions, the evaporating capacity of this oil per pound at 100 per cent. efficiency is 18.3 lb. of water from the temperature given. With a combined efficiency of furnace and boiler of 70 per cent., an evaporation of 12.8 lb. of water per pound of oil burned may be expected. This efficiency might be maintained with a load ranging from 75 to 125 per cent. of full load. For less or greater loads a combined efficiency of 70 per cent. could not be expected. At one-fifth load the efficiency would range from 55 to 65 per cent. and the evaporation from 10 to 11.9 lb., a reduction of 22 per cent. in fuel economy at the lower efficiency. This shows conclusively the importance of operating the boiler plant at as near full load as possible.

Never permit the fireman to work six boilers when the load is just sufficient for five, though he will protest

*Abstract of paper read by J. P. Greenwood before the Practical Refrigerating Engineers' Association, at Dallas, Tex.

against the full load on the five boilers because closer attention is required.

Each boiler has certain peculiarities and must be studied as an individual patient. To determine the proper draft pressure for any certain boiler at different loads, it is necessary to use a CO_2 instrument and regulate the damper and burners for the load so as to secure the most desirable percentage of CO_2 in the furnace gases, which is 14 per cent. when the lowest uptake temperature consistent with draft pressure is obtained. The temperature should be taken just as close to the end of the gas pass as possible.

When the furnace gases are an orange color, never under any circumstances a dazzling white, the correct burner and the proper air mixture have been secured. As the draft determines the quantity of air the importance of the draft gage will be apparent.

In burning natural gas only, the furnace construction and burner equipment will be different. Have as high gas pressure up to the burner exit as possible. Regulate the burners to obtain the proper mixture. In handling fluctuating loads, turn the burners on or off, but do not change the mixture.

Texas Lignite

This fuel exists in great abundance in Texas and the supply will undoubtedly last for centuries. When the price is not prohibitive it is a desirable fuel. It is low in heat-value and therefore requires considerable handling, as more of it must be used to carry the same load.

The average lignite in Texas runs about 7600 B.t.u., and on the same conditions given for oil, it has an evaporative capacity of 7.5 lb. at 100 per cent. efficiency. The average furnace and boiler when burning lignite will have a combined efficiency of about 50 per cent., or an actual evaporation of 3.75 lb. of water per pound of lignite.

In firing lignite at the normal rated load in hand-fired furnaces, the author found that the furnace doors were open for stoking about 15 per cent. of the time. During this period the combined efficiency of the plant is not over 30 per cent. at best, so that it is important to reduce the time of firing as much as possible.

The commercial boiler settings and grates sold in Texas are not adapted to the economical use of lignite. This fuel contains from 15 to 40 per cent. of water; when the moisture is gone the binding quality is removed and the lignite is harder than ever to fire, because it slacks similar to lime and becomes a powder which fills the air channels through the fuel bed and effectually cuts off the draft. Its volatile component forms 20 to 30 per cent. of the fuel, and being a hydrocarbon it is easily distilled when the fuel is first admitted to the furnace. If there is sufficient air and high enough temperature in the furnace, this volatile matter will be burned; otherwise, it will be deposited in the tubes as soot. The farther away the furnace is from the boiler tubes or sheets, the better are the results obtained. The furnace should be about 6 or 8 ft. away from the tube sheet, say in a dutch oven, or lower down than usual.

A half-dutch oven setting for the use of lignite is recommended. A setting with a 2½- or 3-in. air space left between the inside and outside walls, which is filled with equal parts of sand and ashes, is good construction. When a crack develops in the side walls the sand and ash mixture will tend to close it and prevent the air from leaking into the furnace. With a steel casing, be sure that plenty of nonconducting material is used between the brick lining and the casing; otherwise, the heat losses from radiation and conduction will exceed those of air infiltration in the case of a brick setting.

The bridge-wall should be just high enough to prevent the fuel from falling over into the combustion chamber; it has no other function. It is a mistake to build a high bridge-wall and curve it with the boiler, as this simply chokes the gas travel and causes the draft pressure to pull too much cold air through the setting. Natural draft is the most satisfactory.

With a stack of sufficient height to produce a draft of 0.8 in. of water in the uptake and a 150-hp. boiler with 1500 sq.ft. of heating surface to evaporate 4500 lb. of water into steam per hour at 50 per cent. combined efficiency, and an evaporation of 3.75, it is necessary to fire 1200 lb. of lignite per hour. With the average grate area of 25 sq.ft., this is burning 48 lb. of lignite per square foot of grate per hour, to maintain normal capacity. The draft pressure should be about 0.5 in. of water, depending upon the size of the lumps and the amount of slack in the lignite.

On the other hand, the grates may be 6 ft. long, giving a total of 30 sq.ft. of surface. In this case only 40 lb. of lignite per sq.ft. of grate surface would be burned, the fuel bed being about 12 in. thick. Suppose only half load was demanded, then 20 lb. of lignite per sq.ft. of grate must be burned and the draft lowered to secure the best results; but unless the damper is manipulated there will be practically the same draft pressure at all loads. The foregoing emphasizes the necessity of a properly installed draft gage and damper. It would be well to put a draft gage on the uptake and on the furnace. The furnace gage would indicate the resistance to the air through the fuel bed, while the one on the uptake would show the resistance through the boiler tubes.

Lignite calls for a large combustion chamber, so that the volatile matter will have a chance to burn before coming in contact with a comparatively cold surface. A shaking grate with as many small holes as practicable, the percentage of air space being not less than 20 and not more than 30 per cent., is the most desirable type for a hand-fired lignite furnace. Do not make the mistake of getting a large grate surface with 30 to 50 per cent. air opening, and have the proportion of grate area to heating surface 1 to 50 or 1 to 60. If it is a question of capacity, add to the stack and use a thicker fuel bed. Lignite requires little slicing or, on a shaking grate, shaking, but an attendant should slightly move the grates every ten or fifteen minutes, depending on the load on the boiler.

The alternate methods of firing and of cleaning fires is the best system. When cleaning, close off the dampers on the boiler. With a good practical shaking grate, lignite fires may not need cleaning oftener than once in six hours at full load. To establish the proper draft pressure for lignite fires it is necessary to use a CO_2 instrument, and determine the pressure when the gases show about 14 per cent. CO_2. This will be about one minute after stoking the furnaces, and from this instant until the fires are again stoked the CO_2 will gradually drop down to as low as 4 or 5 per cent. A study of the furnace conditions will determine the firing intervals

for best results. The CO_2 sample may be taken over a period of twelve hours or more by using a sampling tank, and making a daily analysis of gas; this will give the average for the time or day of sampling. When the highest average has been established and the draft gage noted, then it is a question of watching the draft gage and regulating the furnace accordingly.

In buying a new boiler always use an 18-ft. tube, or longer, and in water-tube boilers above 300 hp. a double pass for the gases is preferable.

Slack Coal

To burn this fuel economically a furnace similar to one for lignite is desirable, the same general conditions will apply. An automatic type of flue blower would be advantageous, as blowing the tubes when using slack coal is beneficial. Slack coal should be fired in small quantity and evenly spread over the grate surface, and not over 5 to 8 in. thick. If the slack has a tendency to cake, it must be sliced frequently to secure the best results; do not break up the fuel zone, simply run the slicebar under the fuel bed on top of the grates and give it a slight twist and side movement so as to open up air holes.

A shaking grate with 40 per cent. air space will be satisfactory and a tall stack and a strong draft are desirable. A shaking grate should be oscillated every 10 or 15 min., or whenever the ashpit grows dark and no reflection of light from the grates is seen.

Never rock a grate violently, as it does more harm than good. Never use a long grate bar, as the average fireman will not keep the back of it covered, and excess air leaking through and diluting the furnace gases is a serious matter. It may be considered necessary to have a long bar in order to get the desired capacity, but it is better to add more to the stack at any cost, and save fuel thereby in having a stronger draft, a deeper fuel bed and less loss. It is the draft pressure that is largely responsible for the ultimate economy.

A water-tube boiler is slightly more efficient than the horizontal return-tubular type in equal capacities when burning lignite or slack coal, but there is practically no difference when using oil or gas fuel. With a horizontal water-tube boiler a horizontal baffle is preferable and more practical than the unreliable vertical baffle.

Recording Meter Measuring Boiler Blowoff Discharge

A unique use to which the "Lea" V-notch recording meter has been put is in the measurement of the blowoff discharge at the Waterside station of the New York Edison Co. The arrangement is shown by Fig. 1.

Continuous measurement, showing operating conditions of the different factors of the power plant, is becoming more universal in American power plants. It has been the practice for some time to measure boiler-feed water continuously so that the evaporative value of the coal and the efficiency of the boilers can be determined. In many plants continuous records of condensate from individual units are made by which the steam consumption per kilowatt can be compared with previous records. As far as known, however, this is the first case where continuous record is being made of the intermittent boiler blowoff discharge as well as of the blowoff leakage.

Such a record enables the engineer to determine the amount of water evaporated per pound of coal or per kilowatt, because by measuring the makeup water continuously and subtracting from this quantity the blowoff discharge, an exact quantity is left which represents the amount of water evaporated. The total boiler feed in some plants is determined by measuring the makeup water to the heaters, to which is added the condensate from each of the turbine units, equipped with surface condensers, and from this total is deducted the heater overflow and the blowoff discharge.

In the measurement of blowoff discharge there are peculiar conditions, but the recording meter is adapted to meet them because it is accurate at low rates of flow as well as high. Blowoff discharge from a given plant is a fluctuating quantity because the boiler staff may blow down a series of boilers in the morning and then do no further blowing down for 12 or perhaps 24 hr. In the interim, the only water flowing through the blowoff discharge is the leakage from defective blowoff valves. This latter quantity is small in a well run plant, yet it is important for the engineer to have a chart record of this small quantity.

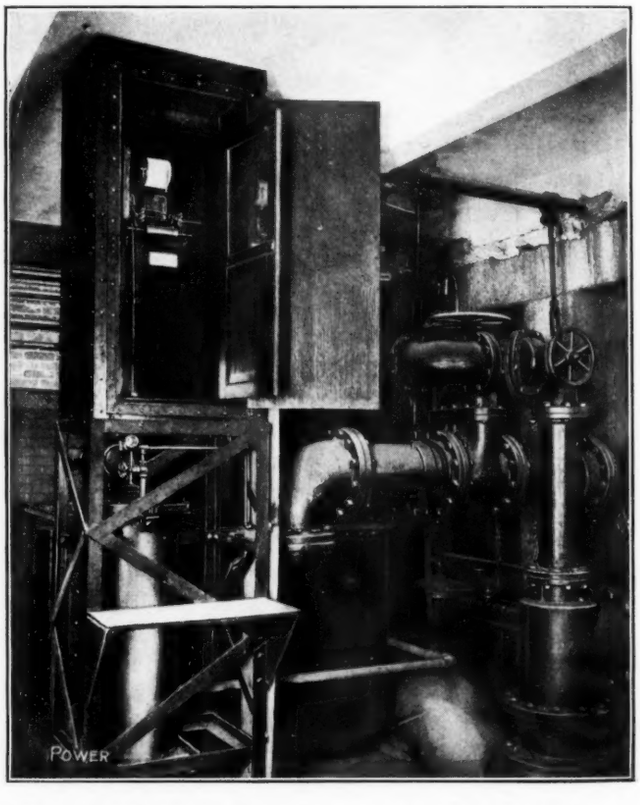


Fig. 1. V-Notch Recorder for Measuring Boiler Blowoff Discharge

The system as installed consists of a heavy steel V-notch tank with a sealed cover vented to the atmospheric exhaust line, Fig. 2. The tank is provided with a partition which contains the weirs. To one side of the tank is placed the float chamber, connected to the central section of the tank, by means of a 2½-in. pipe with a valve

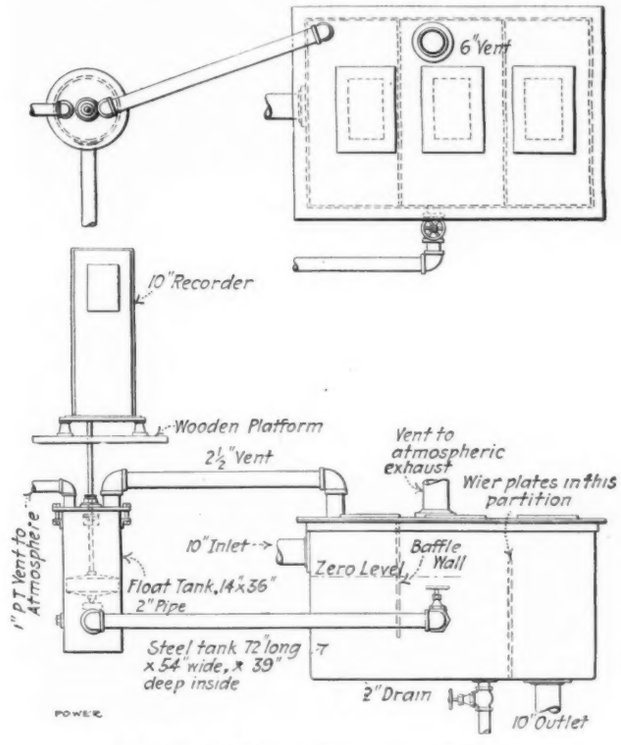


FIG. 2. V-NOTCH TANK AND PIPING

for throttling purposes. The recording instrument is supported on a steel frame over the float chamber. The top of the float chamber is vented over to the top of the weir tank. The float spindle passes through an anti-vapor gland in the float-chamber cover, thence up through the instrument base where another anti-vapor gland is provided to prevent steam rising into the instrument. Here the float rod connects with the instrument rack and operates the recording drum on which is graduated the rate of flow. The slider bar of the instrument transmits to the pen the instantaneous rate of flow and the clock drum revolving draws a curve which is the curve of flow of the water passing through the weirs.

The inlet enters one end of the steel tank from a connection to the blowoff tanks of the plant, and the blowoff tanks are vented so that there is practically no pressure accumulation in the V-notch tank. If there is such an accumulation, a large 6-in. vent relieves it. The discharge from the blowoff tank goes to the sewer.

To increase the range of the recorder two weir plates are used, one of which is a standard one-quarter 90-deg. V-notch (i.e., having one-fourth the capacity of a 90-deg. V-notch), while the other is a rectangular weir whose

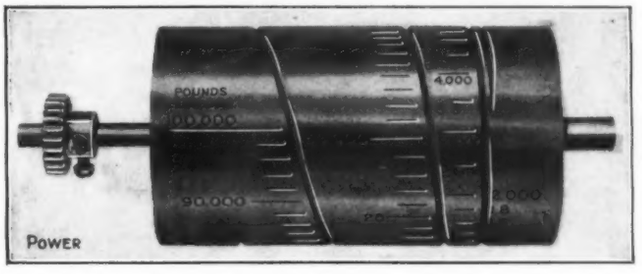


FIG. 3. DETAILED VIEW OF THE CAM DRUM

zero line is elevated 6 in. above the zero line of the V-notch. Water will, therefore, pass through the V-notch until a 6-in. head is passing when the water will begin to flow through the rectangular weir and as the flow increases both weirs will take care of the discharge.

The recording instrument is provided with a cam drum, Fig. 3, cut for the flow through the one-quarter 90-deg. V-notch. In other words, it is a $^5/_2$ curve. By consulting the accompanying chart, Fig. 4, there will be noted a second datum line which represents the zero line of the rectangular weir. To determine the quantity of water which has passed through the weirs it is necessary to planimeter first the area within the curve and then multiply this by the value of 1 sq.in. of the chart, which is the constant of the chart. Then planimeter the area of the peaks of the curve above the datum line corresponding to the zero level of the rectangular weir and multiply this area by a constant, which has been predetermined by the flow over the rectangular weir. These two quantities are added together and represent the total blowoff discharge.

Although the curve of flow of the rectangular weir is a $^5/_2$ curve and the curve of the flow over the V-notch is a $^5/_2$ curve, when comparing at and above the datum line

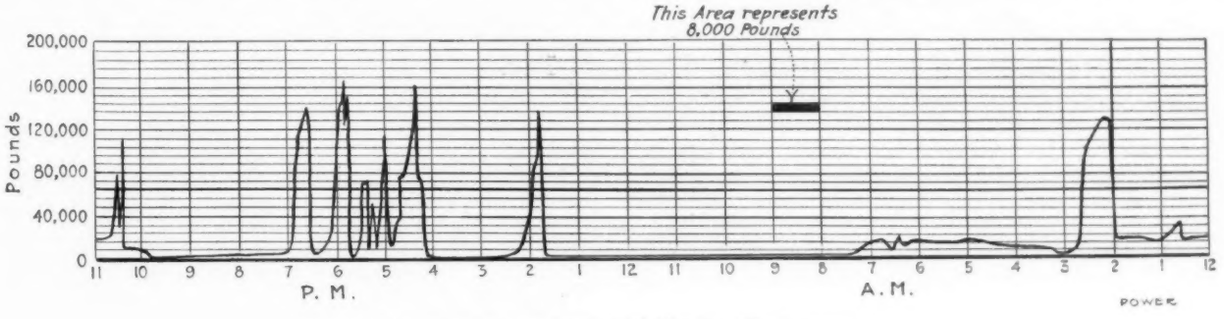


FIG. 4. CHART FROM V-NOTCH RECORDER

above the rectangular weir, they closely resemble each other; hence the small error introduced by the $^5/_2$ cam of the recorder is negligible.

Contract for Panama Exposition Buildings—Contract for the construction of the Palace of Arts and the Palace of Government, two of the reinforced concrete buildings for the Panama National Exposition, have been awarded. The buildings are to be completed by October 1, 1914. The two together will contain over 8000 electric lights.

Difficulties of Transporting

By Alfred Gradenwitz

SYNOPSIS—Some interesting cases illustrating the difficulty of transporting heavy machinery where the needed facilities are lacking or are rendered useless.

Present tendencies of designing central stations for supplying power to large districts and of concentrating their output in a few mammoth generating units, have given rise to transport problems, not always sufficiently appreciated. Some striking instances, for which the writer is indebted to an engineer of Sulzer Brothers, of Winterthur, Switzerland, are given in the following:

In large cities, where transportation is greatly facilitated by rail or by waterways, the erection troubles encountered are relatively easy to overcome. Where conditions are different, transportation may prove so difficult and expensive as to stand in the way of the realization of the whole scheme. In connection with an installation in the Argentinian Cordilleras, the cost of transport rose to enormous figures. Even the masonry walls entailed ten times the usual price. In such cases the bricks have frequently to be conveyed great distances by mules, or by camels, as in Egypt (Fig. 1).

The absence of cranes, winches, trucks of sufficient capacity, etc., may compel the engineer to invent new methods. As an example, large boilers, and even gas tanks, have, like ship hulls, been floated by their own buoyancy on rivers or at the seacoast from one place to the other. This course must be adopted in the absence of transport vehicles of sufficient size, or when they cannot come close to the unloading station. Such remarkable sea trips have been made by some Sulzer fire-tube boilers installed at the lead and silver mines of Almagrera, Spain, near the Mediterranean coast. Since the transport of such big pieces from the nearest railway station to the mines would have entailed extraordinary difficulties, the waterway was chosen in spite of the absence of any harbor accommodation or even a landing bridge. Since the boilers, on account of their mechanical strength, could pass the breakers without any danger, they were readily hauled to the coast from the transatlantic steamer anchored at the roadstead. In a similar case it was possible to drag the floating Sulzer boilers up on an emergency runway made of planks and rollers by means of a shunting locomotive, as the rails reached fairly close to the coast. Figs. 2 and 3 show boiler transportation in Egypt, on the banks of the Nile.

Interesting conditions are frequently met with in countries of small population, considerable distances and lack

Fig. 1. Transporting Stones by Camel

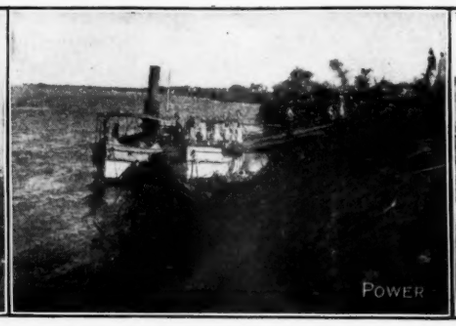


Fig. 2. Transportation on the Nile

Fig. 3. Lowering a Sulzer Flue Boiler

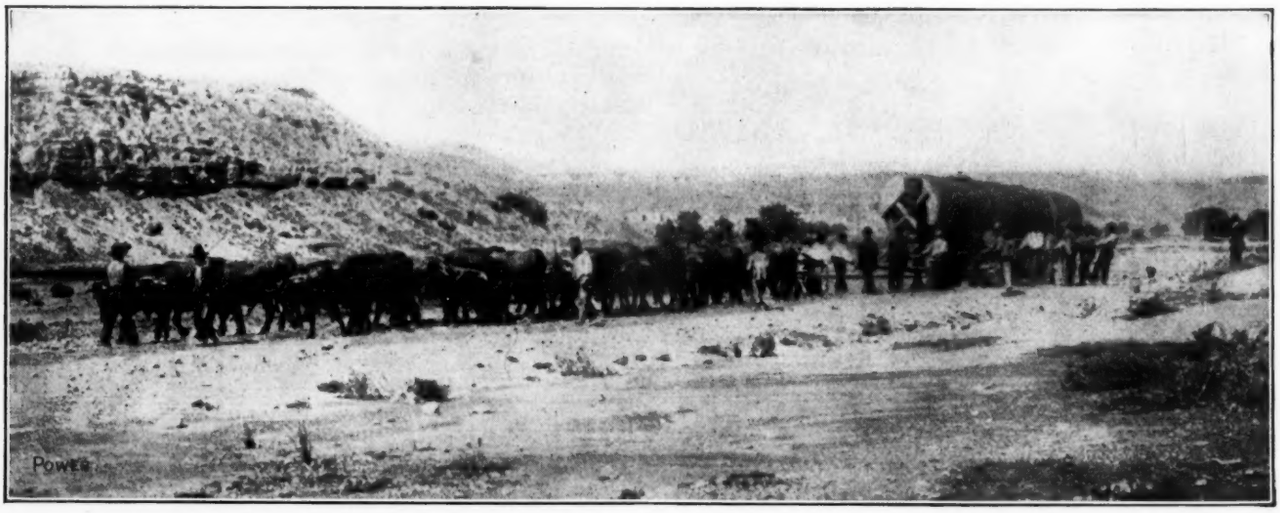


Fig. 4. Oxen as the Motive Force

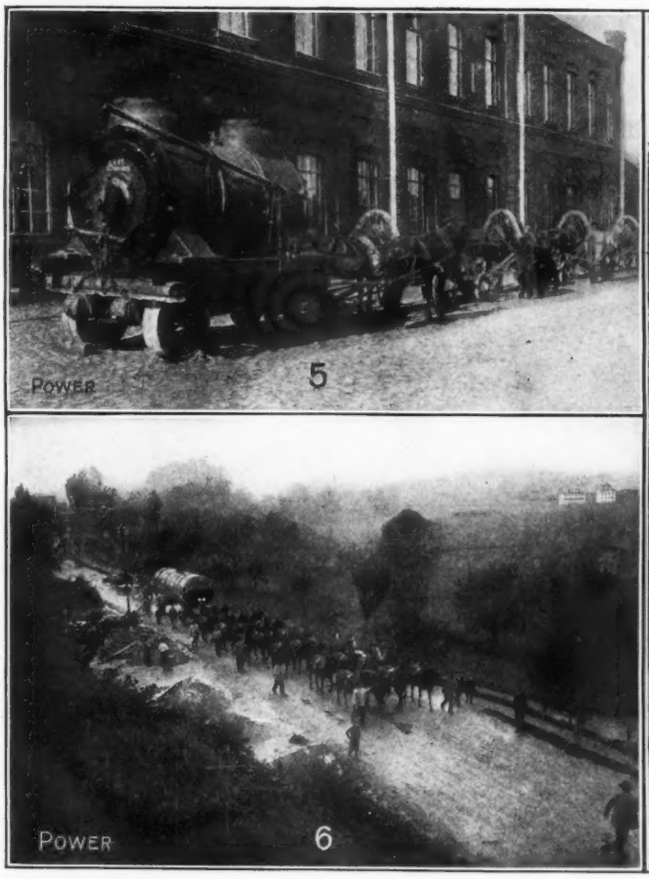


FIG. 5. HAULING AN ENGINE CYLINDER IN RUSSIA
FIG. 6. ON A SWISS MOUNTAIN ROAD

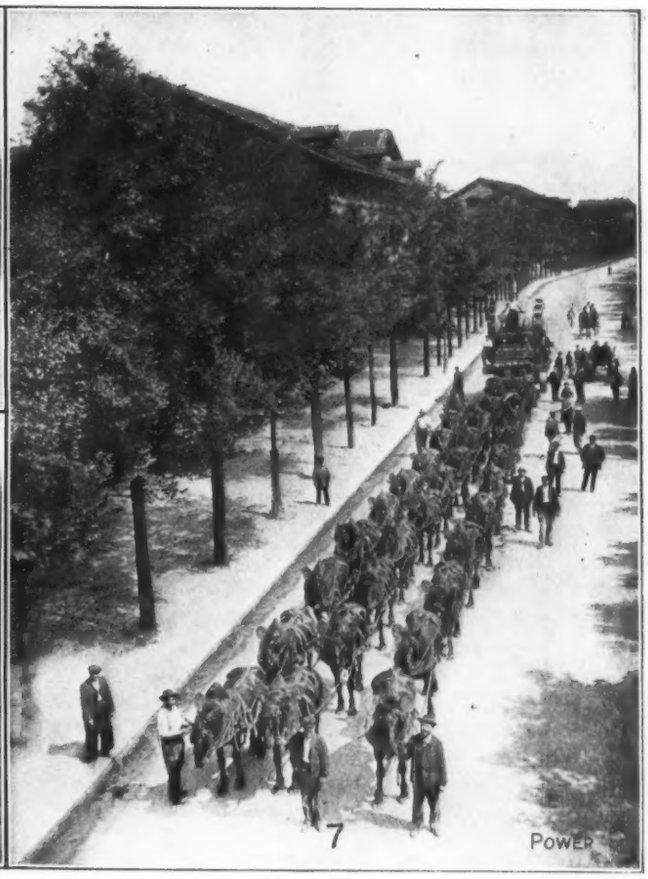


FIG. 7. TRANSPORTING A TURBINE CASTING IN A SUBURB OF PARIS

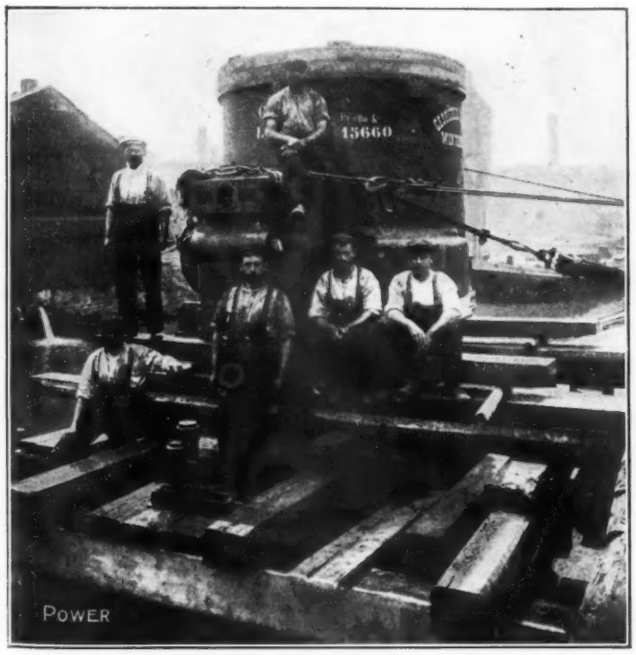


FIG. 8. MOVING AN ENGINE CYLINDER ON TRESTLES ALONG THE THAMES

of railways and waterways. Such countries may not become industrial districts, though industries may develop on account of the necessity of exploiting some treasures of the soil. As mines, spinning mills, corn mills, etc., are found in the most out-of-the-way countries, it is often necessary to convey machinery of considerable dimensions and weights on trucks over country roads.

Such a transport is illustrated in Fig. 4. This mine was not of sufficient size and output to warrant the installation of railway lines. The roads in these countries generally leave much to be desired; the trucks often sink to the axle, and the bridges over the rivers are usually not strong enough to support heavy objects. In transporting a heavy Sulzer steam engine destined for a spinning mill in the interior of Russia, bridges had to be constructed specially for the purpose.

Such transport work is frequently made even more difficult by the lack of unskilled workmen, although this deficiency may be made up by numbers. Fig. 5 shows a Sulzer steam engine being conveyed from a Russian custom house to the site of the power house.

Unexpected difficulties may occur in the winter when the rivers are frozen. A disagreeable surprise was experienced in connection with a large steam engine to be conveyed upstream from the mouth of the Dnieper. Since the river was not free from ice and no delay was permissible in fitting up the engine, it had to be taken to pieces, the parts being transported over the country road to the spot, which, of course, took many days.

Such untoward difficulties may sometimes occur in the largest cities. Fig. 7 represents operations in Paris during the transport of heavy pieces belonging to two large 10,000-hp. Sulzer steam turbines and the electrical generators. Since the central station had no siding and at

the banks of the river, on which the power house is situated, no crane of sufficient capacity was available to allow the waterway to be used, the engine parts had to be transported on trucks from one of the railway stations through the streets of the city, and a special permit obtained for passing the streets and the bridges across the river. Sunday morning was allowed for the work, which took 6½ hr. Several of the heaviest pieces weighed from 77,000 to 88,000 lb.

Fig. 8 illustrates the difficulties of transport in London. The cylinder shown belongs to a 6000-hp. steam engine. There being no other avenue of approach, the parts had to be taken to the site of the power house on trestles alongside the Thames.

Solving the Cinder Problem at Waterside—V*

By Charles H. Bromley

SYNOPSIS—This article, the fifth and last describing the cinder abatement at the Waterside stations of the New York Edison Co., treats of the successful cinder catcher, which has been perfected only after years of experimentation. The gases at high velocity impinge first upon a film of water running over a movable baffle in the main flue, at nearly right angles with the boiler uptakes, and then are projected at a velocity of 50 ft. per sec. into water in the bottom of the flue. About 95 per cent. of the solid matter is removed. The water in the flue is used over and over, and after a 24-hr. run contains 0.025 per cent. sulphurous and sulphuric acids. Copper proves the best material for the baffles.

The New Wet-Process Cinder Catcher

At Waterside No. 2 station six boilers and the 50x90-ft. flue were cut out of service to permit installing the new wet-process cinder catcher, an end sectional elevation of which is shown with the flue and the boiler in Fig. 18.

To one of these main flues six boilers, standing back to back, three in a row, are connected. In the illustration, *A* and *A* are the smoke connections from the boilers to the flue *B*, which has a combined baffle and trough *C* extending the entire length of the flue. Fitting closely to this baffle is a large movable damper *D*, 5x50 ft., extending the length of the flue and poised at such an angle that it comes ordinarily within 3 to 6 in. of touching the side of the flue at *E*, and within the same distance from the surface of the water in the bottom of the flue, the depth of water being about 18 in.

This large damper is counterbalanced by weights through the chain and wheel *F*, the bottom of the damper being held near the flue by the link *G*. In the trough is an 8-in. water pipe *H*, extending the length of the flue and having 1-in. holes spaced at 4-in. centers in the bottom.

Water is taken from the tank by a centrifugal pump, Fig. 19, on the boiler-room floor and raised to the pipe *H*, from which it runs into the trough, overflowing the latter and running in a sheet down over the surface of the baffle *D*, and dropping off (in a sheet) into the tank. About 75 gal. of water per min. per boiler is circulated, and about 8 gal. per min. per boiler is added to make up for that lost by evaporation and spray carried away by the gases.

As the damper *D* is movable and counterbalanced it may be raised or lowered by turning the handwheel *J*; thus when raised, the link *G* will force it away from the side of the flue a distance proportional to that which it has moved above the surface of the water. The fundamental reason for the damper is to increase the velocity of the gases, and the reason for moving it is to allow for increased draft due to increased load on the boilers.

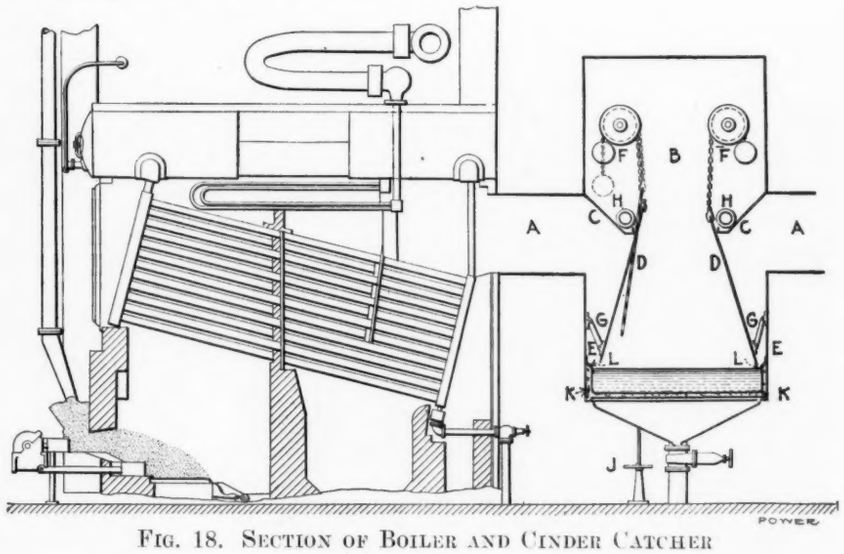


Fig. 18. Section of Boiler and Cinder Catcher

Action of Gases and Cinder in the Catcher

Formerly, the gases passed from the boiler through *A* and into the open flue *B*. Now they come through *A* as before, are deflected downward by the baffle *C*, impinge on the sheet of water on the baffle *D*, and then pass down through the wedge-shaped duct formed by this baffle and the side of the flue. The gases thus attain a high velocity as they rush through the opening at the bottom of the damper. From 10 to 14 per cent. of the

*The cinder catcher described in this article has been patented jointly by Thomas E. Murray and C. B. Grady, of the New York Edison Co.

cinder is taken out by the sheet of water on the damper, and from 80 to 85 per cent. is removed when it is projected onto the surface of the water with the high velocity attained. This velocity is acquired partly by the increased velocity of the gas current and partly by gravity. This is an important feature, for the inertia of the solid particles varies in proportion to the square of the velocity, and the resistance of the projected particles to any force tending to change their direction of travel varies as the inertia. It is estimated that the cinder is projected toward the surface of the water at an approximate velocity of 50 ft. per sec.

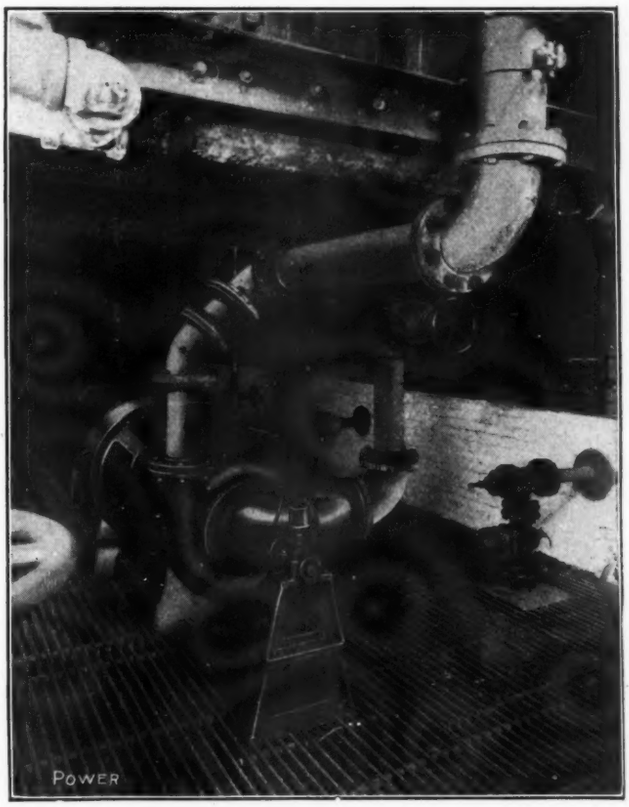


FIG. 19. THE CIRCULATING PUMP

EFFECT OF CINDER CATCHER ON THE DRAFT AND BOILER CAPACITY

The cinder catcher does not seriously reduce the boiler capacity. With a draft at the stack base of from 0.9 to 1.2 in. of water a load of 1500 hp. can be carried on each 650-hp. boiler with only a slight decrease in the efficiency of the cinder catcher. The position of the baffle is always maintained, so that the velocity of the gases leaving the baffle is the highest possible with the stack draft obtainable, thus under normal draft conditions, with boilers operating at 110 and 150 per cent. rating, the baffle opening would be from 3 to 6 in. and increased to 14 in. at 225 per cent. rating.

EFFECT OF ACID WATER ON BAFFLES

The gases at the Waterside stations contain about 0.06 per cent. sulphur dioxide gases which have a great affinity for water. A certain amount of sulphurous acid and sulphuric acid is formed by the gases coming in contact with the water.

As they leave the cinder catcher, the gases carry away some water in the form of spray, and the water in the tank, after a 24-hr. run, contains about 0.025 per cent. of sulphurous and sulphuric acid. A small amount of hydrochloric acid is also formed by the combination of sulphuric acid and the salt in the water.

FIG. 20. DAMPER AND FLUSH PIPES

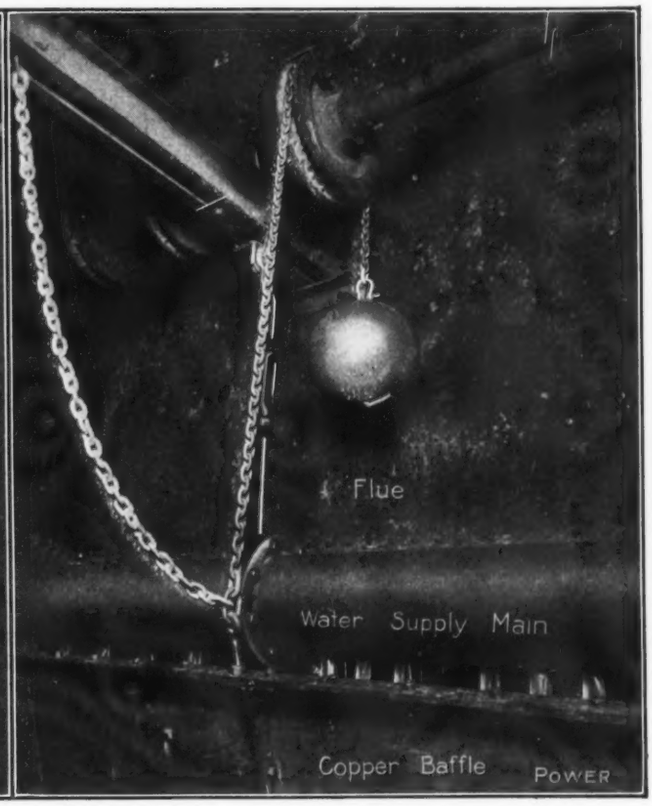


FIG. 21. SHOWING WEIGHTS AND WATER MAIN

These acids have given much trouble, as they are so corrosive that it was exceedingly perplexing to find a material for the baffle that would resist the action of the acids. A sheet-iron baffle was eaten away in two weeks. Then enameled sheet iron, made in furnaces especially constructed to suit the size of the sheets, was used; these sheets failed quickly, as the enamel cracked off when subjected to the heat of the flue and the expansion of the metal.

Asbestos board was next tried; it resisted the acids, but became soft on the surface because of the water, and it soon deteriorated. Experiment was made with a baffle of wire glass, but it broke almost as soon as installed. Glass would be an excellent material, as it will withstand the moisture and acids, but when a hard or flint glass is employed it will not withstand the internal strains to which a baffle is subjected. If made of a highly alkaline glass, and therefore very soft, the heat of the gases so softens the baffle that it warps.

A material very high in silicon was tried, but it too was so brittle that it cracked after a few hours' service. Up to the present, dampers made of No. 8 gage copper, flanged and fastened with 3/8-in. copper bolts, the ends being reinforced with 2½-in. copper bar, have given the best results. The inside face of the baffle over which the water runs shows no deterioration after several weeks' service, but the outer surface has been attacked slightly. Numerous acid-proof and heat-resisting paints have also proved failures.

Flues Painted and Lead Lined

The flues at Waterside are of 3/8-in. steel plate, reinforced with angle irons, and are painted inside and out with linseed oil and red lead. The lead lining, placed in the bottom of the flue forming the water tank, is about 1/8 in. thick, and is laid on a concrete mattress about 1½ in. thick, as shown at *K*, Fig. 18. A copper apron or flashing *L* is all that is needed to protect the lead lining that extends above the surface of the water.

Tests have shown that this cinder catcher has an efficiency of about 95 per cent., which is equivalent to reducing the solid content of the gases to 0.02 grain per cu.ft., which compares favorably with the scrubbers and washers used for cleaning blast-furnace gas.

Fig. 20 shows the damper and the supply lines to the flush pipes in the bottom of the flue. These flush pipes are of 4 in. diameter each, spaced 8 ft. apart, of cast iron, and have holes in the bottom spaced at 4-in centers and pointing at an angle of 60 deg. toward the bottom of the flues, so as to drive the cinder, when flushing, to a hopper at one end of the flue, as in Fig. 18. Fig. 21 is a view of the top of the damper and the water trough.

Cinder catchers constructed on the principle of the one just described are applicable to blast furnaces, cement mills, various metallurgical furnaces, and, according to the inventors, to locomotives, the sparks from which are often so damaging to property.

Arresters in Other Large Plants

The boilers in the Gold St. station of the Brooklyn Edison Illuminating Co., and those in the 201st St. station of the United Electric Light and Power Co., have cinder arresters of the same general design as the one described in this issue. All arresters were made by the Metropolitan Engineering Co., Atlantic Ave., Brooklyn, N. Y.

Notes on Boiler Attachments*

SYNOPSIS—Some practical points relating to safety in the operation of steam boilers.

The Safety Valve

There is no more certain way of blowing up a boiler than by blocking the safety valve. The popular idea that a boiler will explode with great damage by allowing the water to get low and pumping in cold water is not altogether correct. There might be an explosion but certainly not one of any magnitude. When much property damage is reported it can be safely concluded that there must have been considerable water in the boiler at the time of the explosion.

At 100 lb. steam pressure, the water in a boiler is at a temperature of 338 deg. F., and if a rupture occurs, its temperature immediately falls to 212 deg., this loss of heat being taken up by the water so that about 13 per cent. of the weight breaks into steam. A horizontal return-tubular boiler, 72 in. by 18 ft., contains about 20,000 lb. of water at the normal water level. Imagine the effect of 2600 lb. of this water breaking into steam instantaneously. Before it comes to equilibrium with the atmosphere it must expand to 1600 times its volume, while dry steam at 100 lb. gage pressure would expand only seven times its volume. These are only approximate figures, intended to emphasize the great amount of energy stored in the water and the importance of guarding against any condition that may set this energy free.

It is surprising to learn of the number of cases where a stop valve is placed between the boiler and its safety valve. Then there is the fellow who hangs an extra weight on his safety-valve lever to stop it simmering. The engineer in charge of the large, well equipped plant, who would be insulted to find himself classed with the other two, frequently removes the try lever from his pop valve and allows some of these valves to become "frozen" by rust and corrosion from nonuse. He is not very far removed from the man who put the stop valve between the boiler and the safety valve.

With lever safety valves many instances are known where the stem has become "frozen" to the bonnet. Proper care is not always exercised to see that the lever is at right angles to the stem and that there is a proper knife-edge contact between the stem and lever. A flat top to the stem makes a material difference in the distance from the fulcrum, and such a valve may start simmering rather low and not blow strong until the pressure is considerably in excess of the supposed load.

*Abstract of paper by R. T. Burwell, read before the Practical Refrigerating Engineers' Association, Dallas, Texas.

Water Gages and Cocks

The best practice requires that each boiler shall have a glass-gage and three gage-cocks. Where water columns are used, they should be of ample size and be connected to the boiler by liberal-sized connections, the usual standard being 1¼-in. pipe. These connections should be as direct as possible, and wherever elbows are necessary it is best to have tees or crosses with plugs to permit a thorough cleaning of the pipes. The drain or blowoff to the water column, frequently too small to properly flush and test the column, should be of 1- or 1¼-in. pipe and led to the ashpit or out of doors. Such a pipe ending in the boiler room is not only a menace to those in the plant, but it is an indication of carelessness.

One of the most frequent criticisms an inspector has to make is that the gage-cocks are out of order, either stuck or without handles for operating. The man in charge invariably takes offense and thinks the inspector is unreasonable and impractical, since the glass water gage is depended on to show the water level, but suppose the glass breaks and another cannot be put in promptly. It is generally too late then to get them in operating condition. Besides, the management loses sight of the important fact that defective gage-cocks are sometimes troublesome and costly witnesses in case of a boiler explosion.

The Steam Gage

Whenever a boiler is cut into a header already under steam from other boilers, it is extremely important that this boiler be at the same pressure as the header, and this can only be insured by providing each boiler with a pressure gage. The gage should be so connected that its spring will be properly insulated from a hot flue or stack; otherwise it is apt to read incorrectly and its spring may become impaired. In selecting a steam gage, choose one having a back-lash spring, as the gage without this invariably reads incorrectly by a few pounds, due to the back lash in its gearing.

Steam Piping and Fittings

Due thought should be given to the pressure carried and the pipe and fittings selected accordingly. The design should be simple, with a proper allowance for expansion, and it is preferable to make connections from boilers as uniform as possible. All screwed joints should be made with great care as so many serious accidents have resulted from the failure to enter the pipe sufficiently into the fitting. One of the most important points in connection with steam piping is to see that all pockets are provided with drains; better still, arrange the piping so as to avoid pockets as far as possible. The stop valve, for instance, should be in the horizontal portion of the pipe connecting the boiler to the header.

The Blowoff Pipe

That the blowoff pipe is the most generally neglected attachment about the boiler accounts for the many accidents resulting from the failure of such pipes. In the case of the horizontal tubular or flue boiler, the blowoff should be located on the bottom of the shell, as near the rear head as possible to prevent any accumulation or deposit back of the opening. A suitable pad should be provided, as the thickness of the shell alone does not provide sufficient depth of thread, and the greatest care should be exercised in selecting the pipe and fittings to see that all joints are properly made up. Even for low pressures, a blowoff valve of heavy design should be selected and special attention given to the strength of the bonnet.

Where cocks are used, the ordinary plug is to be discouraged since there is too much chance of the plug jumping out in case the attendant knocks it up in his effort to open the cock. A cock held down by a bonnet is preferable, and it should always be remembered that a cock or quick-opening valve should be operated slowly; otherwise serious results may ensue from water-hammer.

The size of pipe is also a material factor in the effects of water-hammer, and for that reason 2½-in. pipe is generally adopted as the safe limit. The blowoff pipe should be protected from the direct action of the fire, and whenever the feed water leaves any deposit, the blowoff valve should be opened at frequent intervals.

It is surprising how clean a boiler can be kept by using a little solvent whenever necessary and opening the blowoff valve about every two or three hours. In doing this better results are obtained if the boiler is not pumped up, since this disturbs the deposit. By frequent blowing it is necessary to blow out only a little water at a time. This applies to feed water in which the solids in solution are precipitated by heat without materially increasing the density of the water. Where a large portion of the solids remain in solution until the density is increased to a certain point, such as in sea water, it is necessary to pump up and blow down.

In most cases the blowoff valve is in a dark, narrow passage between the rear of the setting and the building wall, where there is practically no chance for the attendant to escape in case of the failure of this pipe or its fittings. Where the building wall is close enough, an opening should be made opposite the valve so that the attendant can stand outside of the building while operating it and, if this is not possible, an extension handle could be attached to the valve so that it can be operated from the side of the setting. When the frequency of accidents is considered and that they generally result in serious personal injury or death, the importance of adopting every safeguard to protect those in charge of the boiler can be realized. The failure of a blowoff pipe inside the setting is a serious menace to the fireman in front of the boiler, and this might be lessened by arranging the rear cleaning door so that it will offer the least resistance to the steam and water, and by the adoption of firedoors that will act as a check.

Feed Pipe

The blowoff cannot perform its proper function if the boiler is fed through it. Feeding through the blowoff not only disturbs the deposit and prevents it from being properly removed, but as the pipe is at a much lower temperature than the fire sheets, it produces strains in the material which sooner or later will become manifest in leaky seams and cracked plates. In addition, it generally results in the regulating valve being inconveniently located for the fireman, and if the blowoff pipe fails it is impossible to keep the pump on the boiler until it is sufficiently cooled down. Feeding below the tubes in fire-tube boilers is also open to the objection that it produces excessive strains in the shell plates. The better plan is to let the feed discharge just below the water level. Care

should be taken to keep the discharge end of the feed pipe clear, as it has a tendency to become obstructed where there is any scale-forming matter in the water. Place the feed main and the regulating valves at the front of the boiler in easy and convenient control of the fireman.

Fusible Plugs

These plugs are not always reliable and in certain types of boiler it is doubtful whether they do any good; but their failure to work is frequently due to improper installation or to allowing the filling to become decomposed or covered with deposit from long neglect. If a fusible plug gives a correct alarm once in a hundred times it has done a great service and its presence is apt to prove a friendly witness after an explosion.

In addition to the ordinary fusible plug there is one which melts under the action of steam at about 240 deg. It is placed on the end of a pipe about 2 ft. above the top of the boiler and the pipe extends into the shell to the low-water line. As soon as the water falls to the bottom of the pipe, steam enters, melts the plug and blows a whistle. A valve which can be locked open to prevent tampering makes it possible to shut off the pipe and insert a new plug without closing down the boiler. Highly satisfactory results have been obtained from this device and it is especially valuable for water-tube boilers in which the ordinary plug must be placed at points where the gases are not always of sufficient temperature to melt it and it is therefore an uncertain protection.

Power-Plant Accounts--I

One keeps an account because he wants to know something. The account must, therefore, be kept so that it will tell him what he wants to know. The items which go into it and the method of keeping it will depend altogether upon what use is to be made of it; upon what it is supposed to show, and the first thing to do is to get this *purpose* of the account clearly in mind.

If the purpose of the account is simply to show the proprietor or manager of a business what it costs to run his power department, the account will consist of the summation of the items chargeable to that account. These items may be divided into two groups:

Maintenance	Attendance
	Fuel
	Water
	Repairs
	Boiler compound
	Oil
	Waste
	Packing
	Tools
	Misc.
Fixed Charges	Interest
	Depreciation
	Taxes
	Insurance

Those of the first group ought to be available from the running accounts of the concern.

Attendance

The books ought to show how much has been paid in wages to power-plant attendants. When the time of a man is divided between the power plant and other departments, as a master mechanic who has charge of all the machinery of a mill and really devotes some time and energy to the power plant, or a laborer who wheels ashes and does laborer's work around the power plant a part of the time, their salaries or wages should be charged to the power plant in proportion, as nearly as may be, to the time which is spent upon the power-plant work to the exclusion of their activities in other directions.

It is always a question where to stop in this direction. Some accountants want to charge to the power plant a proportion of the president's salary, of the expenses of the bookkeeping department and of the stipend of the office boy. There it is still a question of what is the purpose of the account. The president of a manufacturing concern of which the power account is a small factor, who knows that his salary is no more because he has a power plant and would be no less if he bought his power ready made, will probably not charge the power account with any of his salary. In an electric company, where the power is the whole product, the administration has a different relation to the power account, and salaries of officers not directly occupied with the plant would go into the costs of the administration of the whole business. The item "attendance" in the first group is intended to cover the money paid for labor and attendance, as of engineers, firemen, coal and ash handlers, boiler cleaners, etc.

Fuel

The books of the company ought to show the amount paid for fuel. So far it is a question of the money paid for fuel, not how much fuel has been gotten for it. The books may not, however, show how much was paid for fuel for the power plant as distinct from fuel for other purposes, as heating and manufacturing processes. Obviously, unless there is some way of determining this principal item there can be no account kept which will amount to anything. When fuel is used for both power and heating, as where the same boilers furnish the steam for both, or where the heating is done with exhaust steam, the question of charges and credits to each of these departments becomes very much involved, and it may be practically impossible to differentiate them entirely, but it is usually possible to keep an account so as to get a satisfactory answer to some particular question, if that question is definitely stated. Whether one credits his power plant with what the heating would have cost if it had been done otherwise, or charges his heating with only extra fuel burned in the power plant by reason of the demand for steam (live or exhaust) used for heating, will depend upon whether he wants to know how valuable his plant is to him in its combined capacity as a source of power and heat, or how much his power would have cost him if there had been no heating to do.

Water

With the water, as with the fuel, it may be difficult to apportion to the power plant its share. Even when the water supply comes from the city or a water company, and the books show the amount of the water bills, it is impossible to tell how much of this should be charged to the power plant unless separate meters are used. Reliable meters are now available at moderate prices. If the advantage of knowing what one is doing, how he is doing it, and why he is not doing better is worth the

cost of such appliances, they should be provided. If they are not, there is no use of talking about accounts. When the water is available, as from a pond or river, it is not necessary to make a separate charge for it, as the items which go to make up the cost of handling it will come in with the other charges. When a water-treating plant is used, the power plant should bear its proportion of the expense of running it.

Oil, Waste, Etc.

Here, again, there must be some way to charge to the power plant only that which it uses. In a factory or machine shop the books will show the cost of oil and waste for the whole concern, but some system must be followed whereby it may be known how much of it goes into the engine room.

Interest

If a man has to borrow the money to buy his steam plant he will have to pay interest upon it.

If he has the money and does not put it into the steam plant, he can lend it and get interest upon it, which he sacrifices if he spends it for a power plant.

In any case, therefore, the interest upon its cost should be included as one of the standing charges against a plant, remembering, however, that any profit which the plant shows over other means of getting the power is over and above the profit which could have been had by investing the money otherwise at the assumed rate.

Depreciation

Suppose an engine costs $4000 and will last 20 years. Then every year the plant uses up not only so much coal and water and oil, but $200 worth of engine. This is true of all of the components of the plant, including the chimney and the power house. Some of them will be used up faster than others. It is usual to charge off about 5 per cent. per year of the total cost of the plant to this account.

If one set aside each year 5 per cent. of the cost of his plant he would, at the end of 20 years, have back the capital which he had invested, and be able to replace the plant, which it is assumed would have worn out in that time. In other words, he is collecting back from the plant in installments the money which he borrowed or appropriated with which to buy it.

Should the plant continue to pay interest on that part which it has already paid?

If interest were really being paid, as upon notes or bonds, the yearly collection for depreciation could be applied to paying that amount of the notes or to refixing that amount of the bonds, so that the interest for the second year would be upon the original investment *less* the depreciation charged off the first year, the investment and interest charge being decreased each year until the debt was paid and the interest ceased. The same reasoning should apply to the general case.

If the object really were to have enough on hand to replace the plant at the end of its assumed life, and the money were really set aside each year as it is charged to the power account, and invested at the rate of interest which it was assumed that one could get when the interest account was established, it would be found that, on account of the compound interest, the total amount would have accumulated long before the time was up. It would take an annuity of less than 3 per cent. to redeem an investment in 20 years at 6 per cent. This sinking-fund phase of depreciation is to be considered in accounts kept for some purposes. The method of treatment will depend upon what the man who keeps the account wants it to tell. It will not make any difference in the amount of money which he spends on his plant, but it may affect the apparent cost of running it.

Upon what is depreciation to be charged? One would charge it upon an exciter unit or a steam pump, but not upon a monkey wrench.

The distinction is this. If the money paid for it is not charged directly to the power account, it may be charged to the investment account and its cost collected within its term of usefulness by charging depreciation upon it. If it is not so treated it should be charged in its entirety as miscellaneous supplies. A belt, for instance, would be charged all at once, and while it would make the power cost high for that month or year, it would average up in the long run. When the capital invested has been all collected through depreciation, this item should be taken out of the depreciation account and the collection of depreciation upon it stopped.

Taxes and Insurance

These items should be available from the bookkeeper. It will still be a question of apportionment, but as both of these items are based more or less directly upon value, they may be taken as a percentage of the cost of the plant. The charge should really be the amount which is paid for taxes and insurance over and above what would be paid if the power plant were not there.

The Waste of Not Using the Water Powers*

Water power is unlike most other natural resources in that it is not diminished by use, nor is it conserved by nonuse. Coal which is not used today remains to be used hereafter, but the energy of water which is allowed to flow by unused neither increases nor diminishes the future supply, but it is irretrievably lost. Our supply of coal—the principal source of energy—while vast, is not unlimited. The utilization of water power results in the saving of coal for future use. In other words, the real waste of water power is its nonuse, while its development effects a conservation, not only of water power but of our fuel supply as well.

The importance of effectively utilizing the water powers of the country is, therefore, obvious. The power now (February, 1912,) required to operate the industrial enterprises and public-service utilities of the country (excluding steam railroads and vessels) can be safely estimated at not less than 30,000,000 hp. Approximately 6,000,000 hp. is now generated by water; the rest is generated from fuel, mainly coal. The quantity of coal required to produce a horsepower-hour in steam varies according to the quality of the coal and the size and efficiency of the engines. It is claimed that under the most favorable conditions a pound of coal can be made to produce one horsepower-hour. From this minimum the estimated quantity ranges as high as even 6 or 7 lb. Assuming, however, that on the average a horsepower-

*"Water Power Development in the United States," by Herbert Knox Smith.

hour in steam can be produced by 3 lb. of coal (and this quantity probably understates the average quantity of coal required and the corresponding saving by the substitution of water power), the power now produced by water saves at least 33,000,000 tons of coal per year. This is based on a 12-hr. day.

By reason of distance from markets, cost of development and other causes, it will doubtless be many years before a quantity equal to even the "minimum potential" water power of the country, 32,083,000 hp., can be advantageously developed. It is certain, however, that under favorable conditions several additional millions of horsepower can now profitably be developed from water, thus effecting a still further conservation of our fuel. The millions of water power economically available, but undeveloped, represent absolute waste.

Calculating Power in Alternating-Current Circuits--II

By Norman G. Meade

SYNOPSIS—Explanation of the terms inductance, reactance and impedance, and their effect in calculating alternating-current circuits.

When making calculations for alternating-current circuits, in addition to resistance one must consider three other factors, inductance, reactance and impedance. Inductance is the coefficient of self-induction and equals the product of the total number of lines of force N threading a coil, when the current is one ampere, and the number of turns T, in the coil, divided by 10^8, or 100,000,000. This coefficient is usually denoted by the letter L, which is the practical unit of self-induction expressed in henrys.

$$L = \frac{N \times T}{10^8} \text{ henrys}$$

If it is known that the number of lines set up increases directly with the current, the above formula may be changed to read:

$$L = \frac{\textit{magnetic flux} \times \textit{turns}}{\textit{current} \times 10^8} \text{ henrys}$$

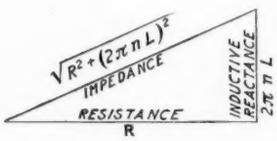


FIG. 8

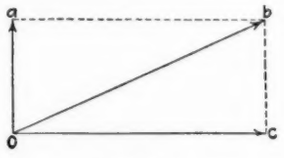


FIG. 9

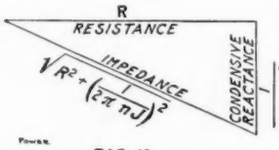


FIG. 10

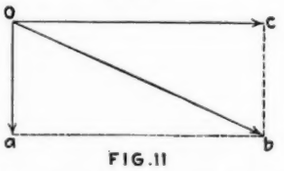


FIG. 11

Figs. 8 and 9 Represent Graphically the Relation between Resistance, Inductive Reactance and Impedance. Figs. 10 and 11 Represent Relation between Resistance, Condensive Reactance and Impedance.

For illustration, assume an electromagnet of large proportions to have the following data:

Total magnetic flux =	30,000 lines
Number of turns of wire =	1,000
Amperes =	1
10^8 =	100,000,000

Substituting in the formula

$$L = \frac{30{,}000 \times 1000}{1 \times 100{,}000{,}000} = 0.3 \text{ henry}$$

Inductive reactance resulting from the counter electromotive force of self-induction equals 2π times the frequency times the inductance in henrys or $2\pi nL$ in which,

$\pi = 3.1416$;
n = Frequency;
L = Henrys.

Like resistance, inductive reactance is measured in ohms.

Considering the same problem as before, assume the electromagnet to be connected to an alternating-current supply having a frequency of 25 cycles. Then the inductive reactance would be

$$2 \times 3.1416 \times 25 \times 0.3 = 47.12 \textit{ ohms}$$

or roughly 47 ohms.

The self-induced or counter-electromotive force is greatest when the rate of change of the current strength is greatest; this occurs when the current is passing from a positive to a negative value; that is, through zero. Hence, the maximum values of the counter-electromotive force and that part of the impressed electromotive force required to overcome straight resistance are displaced 90 electrical degrees.

This is shown graphically by Fig. 9 in which *oc* represents the component of the impressed electromotive force required to overcome resistance and *oa* that necessary to overcome reactance. The resultant is *ob*. This combined effect of reactance and resistance is called impedance or the "apparent" resistance of the circuit—i.e., the quantity which when multiplied by the current will give the total impressed electromotive force.

Bearing in mind the relation in Fig. 9, the value of the impedance may be found by treating the problem as a parallelogram of forces and solving the right triangle, Fig. 8. The base represents the resistance, the altitude inductive reactance and the hypotenuse the impedance. Employing the theorem that the hypotenuse of a right triangle equals the sum of the squares of the two sides,

$$\textit{impedance} = \sqrt{R^2 + (2\pi nL)^2}$$

Let,

I = Current in amperes;
R = Resistance in ohms;
E = Electromotive force in volts;
Z = Impedance.

Then the following relations hold true between Ohm's law for circuits containing resistance only, and the derived formulas for alternating-current circuits containing impedance.

Resistance Only	With Impedance
$I = \frac{E}{R}$;	$I = \frac{E}{Z}$;
$R = \frac{E}{I}$;	$Z = \frac{E}{I}$;
$E = I \times R$;	$E = I \times Z$.

Now, assuming the electromagnet to have an ohmic resistance of 150 ohms, the impedance of the magnet equals

$$\sqrt{150^2 + 47^2} = \sqrt{22{,}500 + 2209} = \sqrt{24{,}709}$$
$$= 157 \text{ ohms} = Z$$

If the electromagnet requires a current of 10 amp.

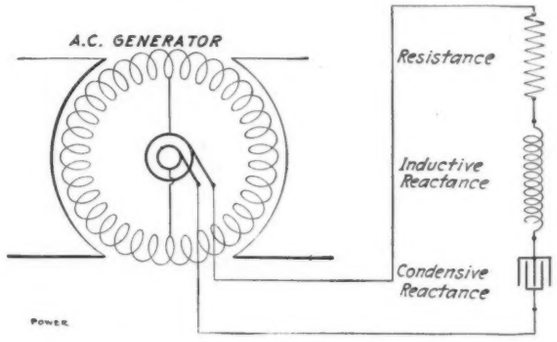


Fig. 12. Illustrating Circuit Containing Resistance, Inductive Reactance and Condensive Reactance.

for its operation, the impressed electromotive force necessary to cause such a value of current to flow through the coil is

$$E = I \times Z = 10 \times 157 = 1570 \text{ volts}$$

In the foregoing problems the current is lagging behind the electromotive force.

Problem—An alternator with a rated electromotive force of 1000 volts at a frequency of 60 cycles per second supplies current to a system of which the resistance is 100 ohms and the inductance 0.3 henry. Find the value of the current, angle of lag, power factor, apparent watts and true watts.

$$I = \frac{E}{\sqrt{R^2 + (2\pi n L)^2}}$$

$$= \frac{1000}{\sqrt{100^2 + (2 \times 3.1416 \times 60 \times 0.3)^2}}$$

$$= \frac{1000}{150.8} = 6.63 \text{ amp.}$$

$$\text{reactance} = 2\pi n L = 113.04 \text{ ohms}$$

$$\text{tangent of angle} = \frac{2\pi n L}{R} = \frac{113.04}{100} = 1.13$$

From a table of trigonometrical functions it is found that the angle corresponding to a tangent of 1.13 = 48 deg. 30 min. Power factor = the cosine of the angle = cosine of 48 deg. 30 min. = 0.662.

$$\text{apparent watts} = E \times I = 1000 \times 6.63 = 6630$$
$$\text{real watts} = E \times I \times \text{power factor} = 1000 \times 6.63 \times 0.662 = 4389 \text{ watts}$$

Condensive reactance, or capacity, is expressed by $\frac{1}{2\pi n J}$ in which n is the same as before and J is in farads. The expression is analogous to that for reactance, $2\pi n L$ in circuits where self-induction is present. The impedance in a circuit containing both resistance and capacity is, therefore, $\sqrt{R^2 + \left(\frac{1}{2\pi n J}\right)^2}$. This is illustrated graphically by Figs. 10 and 11, where the conditions are the reverse of those shown by Figs. 8 and 9.

Let resistance = 100 ohms;
J = 50 micro-farads = 0.00005 farad;
n = 25.

The impedance =

$$\sqrt{100^2 + \left(\frac{1}{2 \times 3.1416 \times 25 \times 0.00005}\right)^2}$$
$$= \sqrt{100^2 + 127^2} = \sqrt{10{,}000 + 16{,}129} = \sqrt{26{,}129}$$
$$= Z = 161 \text{ ohms}$$

Circuits frequently contain resistance, inductive reactance and condensive reactance (capacity). This can be illustrated by incandescent lamps, induction motors and lead-covered cables, as shown graphically in Fig. 12. To illustrate the fact that condensive reactance, causing a leading current, may more than correct a lagging current due to inductive reactance, refer to Fig. 13, in which oa represents condensive reactance and oa' inductive reactance; oc = resistance and the resultant diagonal ob = impedance. Fig. 14 shows the components arranged in the form of a right triangle. Let

$$2\pi n L = 50 \text{ ohms}$$
$$\frac{1}{2\pi n J} = 150 \text{ ohms}$$
$$R = 200 \text{ ohms}$$

Then

$$Z = \sqrt{R^2 + \left(2\pi n L - \frac{1}{2\pi n J}\right)^2} = \sqrt{200^2 + (-100)^2}$$
$$= \sqrt{40{,}000 + 10{,}000} = \sqrt{50{,}000} = 223 \text{ ohms}$$

There will now be a leading current. Synchronous

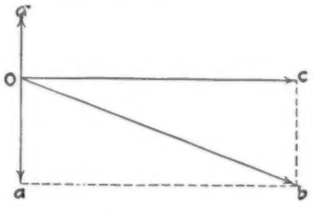


Fig. 13

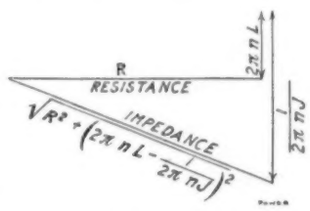


Fig. 14

Graphic Representation of Resistance, Inductive Reactance and Condensive Reactance in the Same Circuit.

motors with an overexcited field possess the same characteristics in effect as condensers and are used to correct the power factor of lines connected to induction motors, as will be explained in a later article. In the last problem, if the inductive reactance and condensive reactance had had the same value, one would have counteracted the other and unity power factor would have resulted.

Remodeling a Small Belt-Driven Steam Plant

By Henry D. Jackson

SYNOPSIS—A change to central-station current did not pay. The difference between power costs as figured by a central-station solicitor and a consulting engineer.

When a manufacturer asks a maker of power-plant apparatus to advise him as to the best machine to install in his plant, he realizes, however great his confidence in the dealer, that such advice may not be entirely disinterested. This being the case, why should a manufacturer rely upon information given by a central-station solicitor as to the cost of power in his plant when considering any changes to improve the operating economy?

He is likely to get advice which is frankly and entirely in favor of the central station. The solicitor is engaged to influence plant owners to install central-station power, and naturally uses every means at his disposal to install this power.

To one plant a central-station solicitor submitted the following figures as to the cost of power under present conditions:

Insurance, taxes and interest	$200
Depreciation	200
Maintenance and repairs	175
Coal	2450
Water	170
Oil	100
Removal of ashes	65
Labor	1035
	$4395

He found that the total power required to operate the plant was approximately 75.6 hp. The plant supplied a number of separate manufacturing establishments, each paying so much for floor space, including power. It was comparatively old and operated entirely by belts, and as each of the floors was controlled by the tenants, the shafting was neglected, so that the friction loss was excessive. The conditions were such that the power plant was very nearly to the limit of its capacity.

The cost of motors required for the electrification of this plant was $2254, and the wiring was $600, these figures being given by the solicitor. He also gave the following estimate of the cost of power under these conditions:

Coal for heating	$450
Removal of ashes, etc.	25
Labor—fireman, etc.	520
Maintenance and repairs	50
Interest, taxes and insurance	125
Depreciation	110
Power	2575
	$3855

These figures show a saving of approximately $540. He also said that it would be better to sell the power to each of the tenants by meters, which could be charged to them at a rate of 4½c. per kw.-hr., thus making an additional profit to the owner of $1250 and a total net gain by electrification of $1790.

These figures were so attractive that the owner accepted them, installed motor drives, dismantled his plant to a great extent, and purchased power from the central station.

After operating the plant for something over a year he was disagreeably surprised to find that the amount of coal burned for heating was considerably in excess of that estimated by the solicitor. He was also surprised to find that the labor cost was considerably in excess of the estimate. This labor was not for firing or for general work about the plant, but was for work in connection with the motors. He was constantly calling in either a man from the central station or from the local electrical contractor to install brushes on his motors, clean up commutators, and to oil and generally oversee the motors. So that his total labor expense on this item amounted to approximately $600 per year, in addition to the supplies which he had to buy. He also found that the oil required for keeping the motor bearings in good operating condition, as well as the waste and other material necessary for cleaning them, amounted to between $60 and $75 a year. These items reduced the gain to less than $1000, and this was largely paper profit.

A consulting engineer to whom the matter was submitted for an unbiased report, gave figures which were decidedly at variance with those of the central-station agent. He called the attention of the manufacturer to the fact that the fixed charges on his original plant as given in the report were at the rate of 24 per cent. per year, whereas the fixed charges on the plant as electrified were taken at a rate of about 10 per cent. It was also found that the fixed charges under the condition of electrification were taken only upon the new equipment, no attention whatever being paid to that portion of the old plant which was still in service, nor was the interest taken into account on that portion of the machinery which had been dismantled and held for sale.

This is an item which is frequently lost sight of when considering making changes in a plant. If, for instance, a plant has a certain value, and for certain reasons it becomes necessary to displace it, the difference between the value it has in place and the value at which it is sold must be taken care of in the new plant, as it is still subject to interest, unless this machinery has been subject to such depreciation charges that it represents merely its sale value at the time it is discarded.

In the case under consideration the engines, boilers, etc., were subject to interest, maintenance, depreciation, etc., and surely if such was the case they were in pretty fair condition, and as the engine and part of the shafting were for sale, the interest charges on these must certainly go on at full value until they are sold, and thereafter at that value minus the price at which they were sold.

In this instance the original plant value had been assumed at $2400; the engine, etc., held for sale at $400; and the cost of the electrical equipment was $2854. Therefore, the total plant subject to interest was $4854, and subject to depreciation, maintenance, insurance and taxes, $3854. Tabulating these gives:

Interest at 6 per cent. on $4854	$291.24
Depreciation at 5 per cent. on $3854	192.70
Maintenance at five per cent. on $3854	192.70
Taxes and insurance at 2½ per cent. on $3854	96.35
	$772.99

As a matter of comparison of interest to the plant owner he was shown that if the fixed charges on this ma-

chinery were taken at the same rate as on the old plant it would give $1006.32.

For operation, the engineer gave estimates as follows:

Coal for heating	$600
Labor	1120
Oil, etc.	60
Water	50
Removal of ashes	15
Cost of power	2575
	$4420

This, taken in connection with the engineer's fixed charges, made a total cost of $5193, or $5426 when taken in connection with the fixed charges at the rate charged by the solicitor on the original plant. As the plant originally operated at a total cost of $4395, the installation of electric motors and the purchase of power increased, rather than decreased, the cost.

The engineer suggested that so long as the electric equipment was installed it might be worth while to install a generator utilizing the old engine to drive it, and also to install a small direct-connected unit for lighting purposes. He submitted the following figures:

Cost of equipment of old plant	$2400
Electric motors and wiring	2854
New generators and switchboard	2070
Total	$7324

Interest at 6 per cent., maintenance and depreciation each at 5 per cent., taxes and insurance at 2½ per cent., would make the total fixed charges $1355.

The average load on the plant was approximately 40 hp., making due allowance for efficiency of generator and transmission between it and the engine.

With the engine put in good working condition the coal would amount to approximately 5 lb. per hp.-hr. The total operating cost for power and heat would then be:

Coal	$1289
Labor at $18 a week	936
Water	100
Oil, waste, etc.	100
Ash removal	50
	$3830

This total also covers the interest, maintenance and depreciation on the lighting unit.

The coal cost for lighting on the basis of 24,000 kw.-hr. for the year would amount to about $270, making a total operating cost of $4100, showing a saving over the original operation by belting and supplying light in addition.

The engineer further intimated that it had been decidedly unwise to take out the old shafting and rearrange the plant, as it probably would have been possible, by thoroughly revamping the plant, to have made a reduction in the original coal bill of about $1300, this being secured by proper lining up of the shafting, overhauling of the belting, and generally reducing the friction loss. With this done, the lighting unit could have been installed as the boiler capacity would have been sufficient to handle it, and the installation of this unit would have allowed the owner to obtain the additional income from this source, which would have resulted in a saving approximately the same as that resulting from the installation of the electrical apparatus without having to go to the same first cost.

Listen to the solicitor but consult your engineer.

Steam Required for Heating Industrial Plants

By Harry C. Spillman

For industrial plants sufficient radiating surface is usually installed to heat the buildings to 65 deg. F. in zero weather. The steam pressure carried on the mains varies from 3 to 10 lb., depending upon the design of the system and the amount of steam required. The following table gives the number of British thermal units per square foot of heating surface at different steam pressures:

Abs. Steam Press., Lb.	B.t.u. per Sq.Ft. per Hr. for W.I.Coils*
6	147
8	167
10	185
12	199
14	213
16	226
20	248
25	274
30	295
35	317
40	338
50	377

*For cast-iron radiators reduce the B.t.u. 10 per cent.

Tests made on a large scale have shown for each month the following percentages of total steam used during the heating season:

	Per Cent.
October	5
November	5
December	15
January	25
February	20
March	20
April	10
	100

It has been found safe to deduct 30 per cent. from the number of days in the season to allow for mild weather and figure the balance for zero requirements.

Take a concrete example of a vacuum system having 20,000 sq.ft. of wrought-iron heating coils. Steam is supplied at an average pressure of 5 lb. gage or approximately 20 lb. abs. The vacuum is about ½ in. at the coils and 10 in. at the pump. The condensed steam from the coils is returned to the boiler at 150 deg. F.

From the first table it is evident that each square foot of heating surface will transmit 248 B.t.u. per hr. The heating system will deliver

$$20{,}000 \times 248 = 4{,}960{,}000 \textit{ B.t.u. per hr.}$$

The heating season has 210 days, and deducting 30 per cent. for mild weather leaves 147 days on which heat is required. This is a safe assumption, as most of the mild days will require a small amount of heat and the majority of cold days will demand heat from every coil. Then during

$$147 \times 24 = 3528 \textit{ hr.}$$

heat will be required. The heating system consumed 4,960,000 B.t.u. per hr. and each pound of steam at 5 lb. pressure contains 1156 B.t.u. above 32 deg. The temperature of the condensation will be about 212 deg., and the heat per pound of water 180 B.t.u. Each pound of steam will therefore give up

$$1156 - 180 = 976 \; B.t.u.$$

Then the heating coils will demand

$$\frac{4{,}960{,}000}{976} = 5082 \; lb.$$

of steam per hour. The heating system is operating 3528 hr., so that the coils will use

$$5082 \times 3528 = 17{,}929{,}296 \; lb.$$

of steam during the season. The steam mains which supply the heating coils will condense 5 per cent. of the steam, and to deliver 17,929,296 lb. of steam to the coils it will be necessary to transmit

$$\frac{17{,}929{,}296}{0.95} = 18{,}872{,}943 \; lb.$$

of steam. As stated, the vacuum pump returns the water to the boiler at 150 deg., and as it is condensed in the heating coils at 212 deg., there is a loss of

$$212 - 150 = 62 \; deg.$$

or 62 B.t.u. per lb. This cause a loss of

$$17{,}929{,}296 \times 62 = 1{,}111{,}616{,}352 \; B.t.u.$$

which is equivalent to

$$\frac{1{,}111{,}616{,}352}{976} = 1{,}138{,}951 \; lb.$$

of steam. The total steam to heat the building will then amount to

$$18{,}872{,}943 + 1{,}138{,}951 = 20{,}011{,}894 \; lb.$$

A pound of coal should evaporate 7 lb. of water, so that there should be required

$$\frac{20{,}011{,}894}{7 \times 2000} = 1429.4 \; tons$$

of coal for the season. By referring to the first table it will be easy to figure out the monthly consumption.

The following results of tests made on modern reinforced-concrete buildings having about 90 per cent. of window area, show the pounds of steam required per cubic foot of volume:

	Lb. Steam
October	0.185
November	0.309
December	0.960
January	1.708
February	1.390
March	1.276
April	0.094
Total	5.922

Safety Suggestions for the Engineer

Wherever "red tape" is frequently a hindrance to the doing of things that the exigencies of the moment require, it is usually so complex as to defeat the very purpose for which it was instituted. When the object of such measures is the safety of employees, the public or of property, an occasional delay, with slight inconveniences, is better than one serious accident or real catastrophe.

Several plants, where high-tension current circuits are controlled from one central-control board, have a system of tagging the switch in a line on which work is being done. The lineman or electrician who is to work on the circuit is given a coupon from the tag tied to the switch, and the switchboard operator must not close the circuit until the electrician returns it to him, the return of the coupon being an indication that the job on the line is completed.

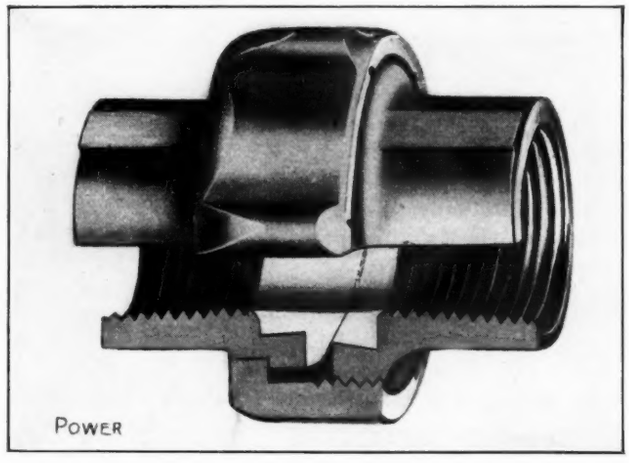
If the valve controlling a branch main on an automatic sprinkler system should be closed, that part of the system would be useless, and serious results might follow an otherwise little blaze. In one factory all the sprinkler valves are numbered and tagged. The tags state that no one shall close any valve in the system without a signed permit to do so, except, of course, in extreme emergencies.

When a valve is closed a red tag is hung over a white one already on the valve, and a coupon from the red card hung on a hook corresponding to the valve number, the hooks being screwed on a board. If a valve must be closed in an emergency, the white card, bearing the date of closure and the name of the person by whom closed, is hung on the board and when the person in charge of the board notices the white card, he immediately hangs the red card on the valve and the red coupon over the white card.

Sprinkler systems are usually in charge of the engineer and he might do well to adopt the above system in his plant.

Rockwood Bronze-Seat Pressed-Steel Pipe Union

The Rockwood union, illustrated in section herewith is made of pressed steel with ground bronze seats so firmly clinched into place that they are practically welded to the steel halves. The bronze ball joint is densified,



SHOWING DESIGN OF PRESSED-STEEL UNION

which is an extra protection against corrosion. In addition, every union is sherardized after threading and previous to grinding, thus protecting the steel surfaces from oxidation.

The nut of the union is so ribbed that in places where it might be impossible to use a wrench, any flat instrument and a hammer will be sufficient to tighten or loosen the nut.

As it is often necessary to take a union apart after it has been in service, the nut is made with slots across the face of the internal threads. By applying a few drops of kerosene, the thread surfaces may be reached by the oil, when the nut is easily loosened.

The union is made in sizes from ¼ to 2 in. The manufacturer, the Rockwood Sprinkler Co., 38 Harlow St., Worcester, Mass., guarantees all sizes of unions to be tight and of sufficient strength, under any pressure of steam, gas or water less than 500 lb. per sq.in.

Editorials

Ability versus Appearance

Is an engineer justified in expecting an increase in salary if, in the performance of his duties, a saving in the cost of power-plant operation has resulted? Furthermore, can he expect the same treatment from his employers if he goes about his work clad in a faded-out suit of overalls and jumper?

To the first question we say "Yes," because ability should be recognized more substantially than by a pleasant "Good morning" and the same flat pay envelope each Saturday.

To the second question we say "No." Although "clothes do not make the man," they have much to do with the way he is treated by those with whom he comes in contact.

The two questions were suggested by two experiences that came to our attention.

An engineer assumed charge of a steam plant of uncertain age and condition. After familiarizing himself with the apparatus he made numerous changes which resulted in dispensing with one boiler, several pumps, five steam engines and numerous steam traps. The saving made per annum was between three and four thousand dollars in the operating expenses of a comparatively small steam plant.

An engineer effecting such a saving would be considered by most people as having made good. But his employers evidently did not think so, or if they did, they failed to show it in any substantial way. After waiting a reasonable time for an increase in salary, the engineer sent a letter to the office asking for it. This occurred weeks ago, but so far no reply has been received.

Doubtless, the engineer made a mistake in writing his request, instead of stating his case in person. Facts can be more forcibly presented verbally than in writing and arguments can be made to offset any unfavorable attitude taken by the employer.

This engineer is accustomed to dress while on duty in the regulation engineers' overalls and jumper. His appearance about the works is that of any ordinary workman, and his superiors doubtless treat him as one. He is wondering if it is because he is judged by his clothing and appearance instead of his engineering ability.

Appearance does count. Another engineer noticed that when he went to the office he was treated with but little consideration. The clerks and others acted as if they were afraid the office furnishing would be soiled from contact with his engine-room clothes. It was, "Here, you, there is that valve you want over there," or "Say, you, what is the matter with the steam heat this morning?"

This engineer decided to change this attitude of his fellow workers. He proceeded to wear a fairly good suit of clothes about the works, and a few "frills," such as a clean collar and tie. He began to assign repair work and such to his assistants and assumed the position of a chief engineer. Result: he is no longer greeted with a "Here, you," but with "Good morning, Mr. Blank." If his presence is required in the office the message is "Will Mr. Blank kindly step into the office when convenient," instead of a summons by the ringing of a bell.

Now, this engineer was just as good a man when he wore his working clothes as he is now, but his appearance belied his ability, and judgment was based on what he wore instead of what he did and could do.

This kind of snap-judgment treatment may not obtain in all cases, but it is more general than is realized. It is a natural attitude, and the fault is with the engineer. Employers like to see a clean engine and boiler room, and a neat-appearing engineer is also appreciated.

Stopping the Wastes

For the thoughtful there is much to ponder over in the forthcoming third annual report of Joseph A. Holmes, director of the Bureau of Mines. In the past year the bureau has done a notable work in reducing the wastes of the mineral resources now estimated to amount to not less than a million dollars a day. What it has done in one year in stopping some of the waste of natural gas alone has effected a saving of ten millions, or more than six times the total cost of the bureau's investigations to date. Had it better facilities and more funds it could accomplish more.

The present methods of producing oil are wasteful and it is necessary to show the individual operators that considerable can be saved without stopping the drilling for oil. It is the practice to waste the gas to get the oil. In the Oklahoma gas and oil fields natural gas is still being wasted to the extent of some fifteen or twenty million dollars worth annually, and in all the fields of the country, over fifty million. Of this, eighty per cent. is believed to be easily preventable and the rest capable of yielding gasoline by extraction, or of being burned for useful purposes.

If the researches and investigations of the bureau, limited as they have been by lack of funds, have enabled the saving mentioned, certainly the appeal for an increased appropriation should be heeded to put added facilities at the bureau's disposal.

Besides the waste of natural gas, there is a large loss of the lighter oils produced from petroleum in pumping and handling. Also, through the flooding of oil and gas strata by underground water, heavy losses are sustained that might be reduced if the conditions could be studied and remedies applied.

Another serious fuel waste occurs in coal mining; apparently 250 million tons is lost annually in mining and handling. A thorough underground survey and examination at selected areas in each of the principal coal fields, in the belief of Director Holmes, would indicate ways to adopt less wasteful methods. This, it is estimated, could be done at the relatively trifling expense of fifty thousand dollars per annum for three or four years and probably effect the saving of a thousand dollars for each dollar expended.

With such opportunities before it for valuable service to the country, when the bureau is properly equipped, it goes without saying that the director's recommendations should not fail to receive attention. Here are definite proposals for real conservation. The country is awaking to the need of it, but Congress is much occupied with the many perplexing questions of foreign policy, tariff, rate regulations, interstate commerce, control of monopolies, water-power rights and so on *ad infinitum*. It is to be hoped, however, that in the crowd of all the other urgent and worthy subjects for consideration, Congress will not overlook this opportune time to further the deserving work of the Bureau of Mines.

No Wonder!

An explosion occurred at Arlington, Mass., causing a property loss of upward of twenty-five hundred dollars. While not a boiler of the variety most dealt with by engineers, no doubt it was a steam boiler before it became a projectile. It was a twenty-gallon copper tank fitted with a hand-regulated gas burner (which was left burning), to heat water for domestic use. The press reports have it that the cause of the explosion is "declared a mystery," and advance some fine-spun theories, but the mystery vanishes promptly, when it is known that the water-supply pipe was fitted with a check valve, which prevented the water from backing up and that there was no relief valve attached.

About as mysterious as the loss of the horse's head to the rider (sober?) who had mounted facing backward and could find only a strip of the mane—neither investigator looked in the right place.

Think of the energy stored in that tank in the form of heat and pressure ready to convert the water into steam as soon as it was released.

Another explosion occurred within a few hours in an apartment house in Brookline, Mass. Fourteen are reported injured and there is a property loss of thirty thousand dollars. The reports are so similar that they appear to have had the same "mysterious" cause. In this case "the copper tank was actually turned inside out" and "probably accumulated a pressure of two hundred and fifty pounds."

Sounds like a check valve in the supply pipe, and no relief valve again. The mystery is why men connect up tanks or boilers in such a way.

Wireless Transmission of Electrical Energy

Although electrical energy has become so commonplace that its use is regarded as an incident, it is within the memory of the most of us when its simplest applications were all curiosities. The engineer of the electric-lighting plant, modern thirty years ago, if he entered the power plant of today, would find it difficult to understand the use and operation of the numerous electrical devices found therein.

The strides that have been made in this branch of engineering have surpassed the wildest dreams of thirty years ago. On one occasion a professor of electricity, solemnly stated to his class that the trolley car would always require a trolley wire as a means of electrical transmission. Today street cars are successfully operated by means of storage batteries. The professor spoke according to the light of his time and could not see the developments destined for the future.

One of the greatest overhead charges against the electric lighting plant is the cost and maintenance of the transmission lines. Although, doubtless much thought has been devoted to the question of transmission-line elimination the problem has remained unsolved. Possibly the invention of wireless telegraphy has given inventors the key which will enable them to perfect a method of wireless electrical transmission.

The advance along this line is promising, for, according to reports, apparatus has been devised whereby electric lamps have been lighted at a distance from the generating apparatus without the aid of transmission lines.

What the success of this invention will mean is impossible to predict. With the first step taken in wireless transmission of electrical energy, it would seem plausible to predict that not only will our buildings be lighted by wireless electrical energy, but that they will be heated as well. In the same manner, commercial electrical energy could be transmitted for motor service.

It may be early to forecast what the forthcoming results of this new invention will be, but who would care to dispute that energy will soon be transmitted from the point to point without the aid of transmission lines?

Questions, accompanied by insufficient data, are frequently submitted to us by correspondents. While it is appreciated that, out of consideration for our time and patience, correspondents may hesitate to explain some facts and conditions for fear they are irrelevant, it is better to do so than to leave us to conjecture as to details which prove necessary to the solution of their problems. We are always glad to overlook such misconception of essentials, but it will contribute more to the purpose to have surplus data than to omit reference to a single detail of conditions that may be pertinent to the inquiry. We wish to make our answers to inquiries sent by correspondents as valuable to them as possible and to do so, we must have complete and accurate statements of the conditions affecting the questions.

It is incumbent on engineers to become versatile, cultivated men. If we cheapen ourselves by avoiding or slurring those subjects which educate us as men, because we cannot see that they aid us as bread-winners, our profession is but little more than a trade. We will receive lower money returns than lawyers and surgeons, and our opportunity for high service will be lessened.—*Shenehon.*

When we receive a contribution accompanied by a request such as this, "Kindly do not print my name in connection with this article as the ———— Co. does not approve of its employees writing for magazines," we get a pretty strong sidelight on the company. While entirely willing to withhold the contributor's name, we would like to print the company's name so that it might get the reputation it deserves.

Mr. Demorest's opinion that an over-lean mixture will cause backfiring in the intake pipe, as expressed on page 281, seems a departure from the generally accepted theory and should form a basis for profitable discussion.

Correspondence

Emery around a Dynamo

In addition to the objections to emery around a dynamo, as stated in the Jan. 6 issue, under "Inquiries of General Interest," it is important to observe that if emery cloth is used for smoothing down a commutator or fitting brushes, loosened particles of emery are likely to lodge between the commutator segments.

As emery is a good conductor of electricity, this will cause short-circuits between the bars. For the same reason, emery cloth should not be used for truing up the brushes as particles of emery or of copper dropping from the brushes cause sparking and burning. For these reasons, as well as to guard against cutting of journals, emery or emery cloth should not be used on a dynamo for any purpose.

FRANK GARTMANN.

Milwaukee, Wis.

Inspecting a Return-Tubular Boiler

The article in the Jan. 13 issue, by James F. Hobart, seems to be lacking in many details and some of the essentials. Steam-boiler inspection is not only for detecting defects, but to make reasonably sure that a boiler can safely carry the pressure allowed, and to note its condition as to scale, oil, etc.

From the second paragraph one might infer that small vertical boilers were the only ones which did not permit of an internal inspection from the inside, whereas many small return-tubular boilers do not permit of such an inspection.

When cooling a boiler the author could have told how to adjust the furnace doors and damper so that the air may be made to circulate through and around the boiler after the doors in front of the tubes have been opened. Usually, when the boiler attendant wants a circulation of air through and around the boiler, he opens the damper and furnace doors and keeps the doors in front of the tubes closed.

Inspectors in this district usually wear a complete dustproof suit, consisting of hood, jacket and trousers, all in one garment, and not with a separate hood as stated; long-legged boots of light weight are worn in preference to shoes. One of the most important accessories in an inspector's kit is an acetylene lamp, or a candle holder and candles, to provide light during the inspection.

In stating what to look for when noting the condition of the setting, Mr. Hobart might have gone further, stating that the brickwork should be examined for loose and bulged walls, for settling of the walls and burned lower furnace walls.

Evidently an error has crept into the article where it is stated that if the front brickwork burns out or falls down, the dry sheet will burn. The paragraph concludes with the statement that this cannot happen with a full flush-front boiler. Evidently a full extension or overhang front is meant, as such a front overcomes the trouble as the dry sheet is outside of the furnace front.

Regarding leakage at the seams, it would have been well to mention that more than overheating of seams is a cause of distress; such as leaks caused by strained plates, due to poor construction and the use of the drift pin, cracks due to inferior quality of metal, or because of long service and by allowing cold air to strike the seams.

Not only will dirt or scale cause bulging and bagging, but the probable cause will be from oil getting into the boiler and mixing with the dirt and sediment and becoming deposited on the fire sheets. In inspecting a bag on a boiler it is important to ascertain how much the plate in the bag has been burned. The hammer test will tell this to the experienced inspector. Even small bulges when they are deep are usually forced back to place, and when the plate is cut out at the bag, the patch is always riveted to the inside of the boiler, where possible, so that a pocket will not be formed.

Mr. Hobart says that all longitudinal seams should be looked after to ascertain if they leak and he also tells what may be seen along each of the outside straps. Generally these joints are concealed by a covering or by brickwork that would have to be broken away before the joint could be seen; that this is seldom done unless signs of leakage give warning that the joint needs attention.

The last paragraph states that girth seams of boilers give little trouble. This should be true of all return-tubular boiler seams, but we find the seam that gives the most trouble to be the front girth seam over the fire. It is difficult in a great many boilers to keep this seam tight, owing to stresses created through the mode of firing.

THOMAS A. RAY.

Boston, Mass.

The Staten Island Explosion*

There seems to be some doubt in the minds of those who have investigated this accident as to its cause. While it appears to have been found that the lower bumped head of the mud drum was slightly weakened by corrosion and possibly the metal of the head at the turn of the flange damaged by a breathing action, there was apparently sufficient metal left (assuming its strength was not seriously impaired) to have successfully held the head unless it had been subjected to a shock.

The theory has been advanced that the braces attached to this lower head may have been broken, due to overload or to defects in the brace material, and in breaking have thrown a sudden load on the head which it was not able to withstand. This is a plausible explanation, and one that appeals to the writer as possibly being the best to explain the accident.

*See "Power," Nov. 4, and Dec. 30, 1913.

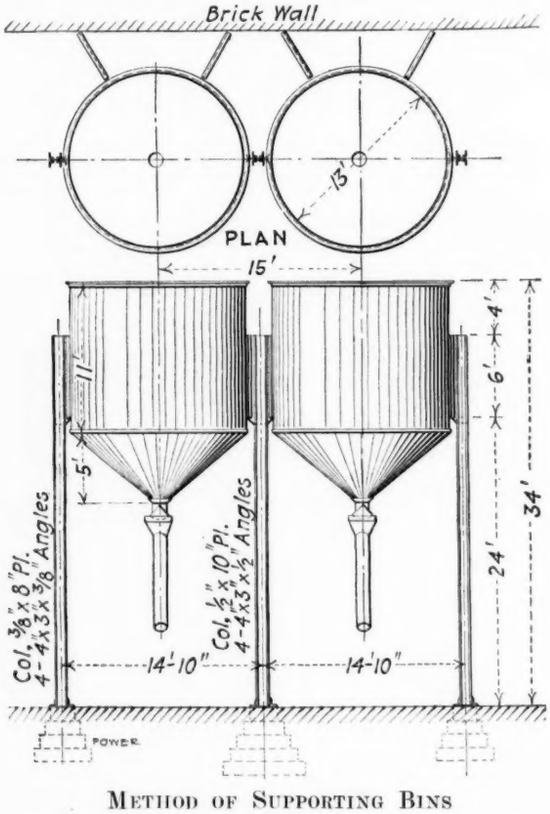
There is, however, another reasonable explanation. The boiler, being of the vertical type, was probably subject to vibration due to pulsations in the steam line, which may have weakened the connection to the steam main or have caused the failure of some pipe fitting near the connection to the boiler. If a break at the main steam connection had caused an opening of considerable size to be suddenly formed in or near the top drum, the result would doubtless have been a sudden rise of water level (filling the steam drum) and this would have produced a water-hammer effect in the mud drum, with the force exerted in a direction tending to knock out the bottom head. It is fairly common to find the plate material in the vicinity of steam-pipe connections on boilers damaged by vibrations of the steam line; and often such vibrations cause injury or weakness in other parts of the boiler.

J. E. Terman.

Hartford, Conn.

Steel Coal Bins

About five years ago the writer designed a steel coal bin for overhead storage that certainly has one thing to



Method of Supporting Bins

recommend it—cheapness. At the time, there was some opposition to the design, but it has given satisfaction.

As shown in the drawing the bins are 13 ft. in diameter with sides 11 ft. high and a 5-ft. hopper bottom. They were erected in pairs, supported on three columns and tied at the top to the boiler-house wall with steel angles. Ten of these bins were erected, one for each boiler, and the total cost, including concrete footings, columns, gates and spouts was $6000, the work being done by contract. The capacity of one bin is 50 tons of bituminous coal. The plates in the sides and bottom are ⅜ in. thick. As erected, the columns had no bracing, the intention being to brace the columns after the gates and spouts had been satisfactorily located, but so far as the writer knows, the columns have never been braced. Of course, should anyone remove the brick wall at the point of lateral support the result would be bad.

C. O. Sandstrom.

Kansas City, Mo.

Engine Stopped When Speeded Up

Some time ago I was sent for by the owner of a 12-hp. portable gasoline engine employed in driving a hay bailer. The engine, of horizontal type and equipped with a gasoline pump and mixing valve, appeared to work all right when running at low speed, but when speeded up it would slow down and stop after a few revolutions. The usual routine of scraping all electrical connections, polishing contacts, etc., was resorted to, only to have the engine repeat its performance.

Looking over the gasoline pump, I found everything apparently as it had left the factory; however, there was considerable vibration as the engine began to increase its speed. After it had stopped, the puzzling part was the abundance of gasoline in the mixing chamber, indicating that the pump was doing its work.

Then I decided to run the engine with the cover of the mixing valve removed and, as the engine started to speed up, all the gasoline vanished; as it slowed down again, about the last two revolutions, the valve refilled. I next cut a small piece of steel wire from a fish line and made two spiral springs, placed them on top of the ball valves in the suction and discharge, the engine was started, and everything was all right.

The cause was that upon speeding up the engine the rapid oscillation of the pump piston lifted the balls off their seats and the vibration kept them rolling around the edge of the seats, making the pump lose what gasoline it had raised, but as the engine came to a stop the balls would roll back just in time to retain some gasoline in the mixing valve.

Frank Hudson.

Ager, Calif.

Criticises Company's Attitude

An article in the Jan. 6 issue shows how the engineers and firemen are regarded by some big manufacturing companies. Mr. Hickstein says: "There was no money to establish a bonus system," to stimulate the firemen to better work. Concluding, he says that the recorders, by means of posting each man's record, have saved the company an average amount on the daily coal bill sufficient to pay the firemen's wages.

Now this amount, it might be said, represents clear profit to the manufacturers and instead of dividing evenly, by means of a bonus system, with the men who are making this profit possible, they want it all.

Mr. Hickstein says these firemen are nearly all "illiterate foreigners with no hope of advancement." Is this same company, that is big enough to have an annual coal bill of $250,000, spending anything to develop these foreigners by furnishing reading and study courses, etc., so they may gain some hope for advancement?

H. U. Cooper.

Kasson, Minn.

Experiences of a Gasoline-Engine Trouble-Man

A contracting concern purchased a 20-hp. gasoline engine from a manufacturer located in western Pennsylvania. When the engine arrived it was set up and started. The purchaser got the idea that the spark plug furnished was inferior as compared with another which he had been using and he accordingly bought one and used it in the engine, or rather tried to use it, in place of the one furnished. The owners fooled with the engine for two days and then telegraphed to the manufacturer that the engine would not run and to send a man to fix it.

This man found that when the compression relief cock was open for starting, the charge in the cylinder would explode, but when the engine approached anything like full speed, it would suddenly stop. He removed the spark plug, found the terminals about $\frac{5}{32}$ in. apart, and, having bent them together until they were separated about $\frac{1}{32}$ in., he replaced the plug. The engine was then started and ran all right. This man traveled over 30 hr. continuously to reach the customer, and all for about 10 min. work. He was absent from the shop for five days.

Another case of trouble encountered by this man on the same size and type of engine occurred in Montreal, in December. He started up and found that half load would slow the engine down to about half its rated speed and that three-quarter load would stall it. As the compression and ignition were all right, obviously the only trouble left to look for was in the mixture. He finally discovered that the piston was upside down, the engine being horizontal. As the engine operated on the two-stroke-cycle principle, this brought the deflector on the bottom and over the exhaust ports, preventing complete expulsion of the exhaust gases and proper scavenging of the cylinder. The piston was turned right side up, the cylinder head replaced and the engine carried its full load at its rated speed.

PHILIPS MIHLEDER.

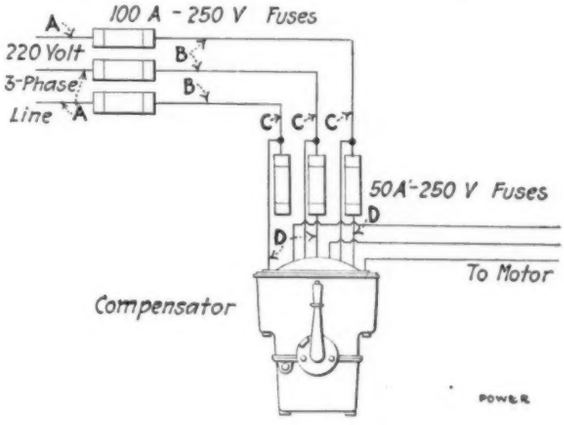
Brooklyn, N. Y.

Unbalanced Phases with Induction Motor

In a test recently made upon a centrifugal pump direct connected to a three-phase induction motor it was necessary to measure the input into the motor. The motor is normally rated at 15 hp., at 220 volts and 35.5 amp. and is started with a compensator connected as shown in the illustration. The motor should have drawn about 10 amp. running light and about 16 amp. when connected to the pump, the pump being unprimed, at a balanced voltage of 220 between any two lines. On the test, however, the following results were obtained: Line voltages 220, 200 and 176, and line current (measured in one phase only) 35 amp.

The first conclusion was that the motor was running single phase, but it started all right and therefore three-phase current was being used. Next it was thought that a poor contact in the compensator was the cause, but the contacts were all cool. A voltmeter was used to trace out the trouble. Voltages at *A* and *B* were taken and found to be all right; also, voltages at *C* were found to be balanced and all equal to 220. With the motor running, the previous unbalancing was again found at *D*.

The motor was then stopped and the fuses removed. They were examined and the telltales were found unburned. Then the fuses were put in one at a time and the voltage measured from the line side of one to the motor side of the tested fuse. It was then found that one of them had burned out, leaving the telltale intact. The compensator, as is usual, starts the motor from the line side of these fuses so that the starting was from the three-phase line, but on the running position the



MOTOR-STARTING CONNECTIONS

blown fuse caused single-phase operation. Once started and up to speed any polyphase induction motor will run single-phase but at about double the three-phase current. It happened in this case that the ammeter was inserted in a live line.

F. G. SWITZER.

Ithaca, N. Y.

Carburetor Troubles

In his article on "Carburetor Troubles and Symptoms," in the Dec. 30, 1913, issue, A. L. Brennan stated that, "An over-lean mixture will often cause backfiring in the intake pipe or carburetor." This statement is correct but not complete. A backfire is caused by the introduction into the engine of a very slow-burning mixture, in which combustion occurs during the working stroke, the exhaust stroke and part of the admission stroke. Thus when the inlet valve opens and admission of fresh mixture occurs, it meets in the clearance space gases in which combustion is still going on, instead of products of complete combustion. These burning gases will, of course, ignite the incoming charge and cause a backfire.

Mr. Brennan seems to neglect the fact that over-rich, as well as over-lean, mixtures are slow burning, and are therefore just as likely to cause a backfire. It is a common mistake to attempt to distinguish between over-rich and over-lean mixtures, with regard to their effect on the proper running of a gas engine, but there is really little, if any, difference between them, from that point of view, except that an over-rich mixture causes a greater waste of fuel. Any gas present in the mixture, and not entering into the combustion, retards the velocity of propagation of the flame.

WILLIAM J. DEMOREST.

New York City.

Inquiries of General Interest

Approximate Rule for Engine Horsepower—What is a short rule for estimating the horsepower of a single-cylinder engine?

J. O. I.

Square the diameter of the cylinder in inches and divide by 2. The rule will be approximately correct for 35 lb. m.e.p., and a piston speed of 600 ft. per min., or whenever the product of the mean effective pressure and piston speed is approximately equal to 21,000.

Volumetric Efficiency and Compression Ratio in Gas Engines—What is the difference between volumetric efficiency and compression ratio as applied to the gas engine?

C. P. R.

Volumetric efficiency is the ratio of the volume at atmospheric pressure corresponding to the actual weight of mixture drawn in, to the volume equivalent to the piston displacement. It is dependent upon the density of the charge and the friction through the intake. The compression ratio, on the other hand, is the volume before compression divided by the volume after compression. It is dependent wholly upon the cylinder dimensions and clearance.

Stopping Cracks in Boiler Settings—How can the cracks of boiler settings be stopped up to prevent infiltration of air?

N. C. E.

To be permanently effective the material used for filling the cracks should be of such nature that it will adjust itself to subsequent expansion and contraction of the walls of the setting. For the purpose a semiplastic material such as loam and molasses, or tar with infusorial earth, or pulverized fillings of clay and infusorial earth confined by asbestos wool have been used. A method which has proved effective for closing small cracks from the outside of the walls is to cover the cracks with strips of muslin fastened with broad-headed nails and spread with a coating of thin plaster. Any filling or covering of the crevices should be done when the walls are cold.

Nonfreezing Compound—What is a good nonfreezing compound for water kept in barrels or buckets for use in case of fire and how can the water be kept sweet?

W. D. G.

Adding to the water 2 lb. of common salt, or of commercial chloride of calcium to each gallon of water will prevent freezing at temperatures down to about 15 deg. F., or lower, according to the strength of the solution. To prevent unpleasant odors arising from keeping the water a long time, the containing vessels should be perfectly clean before being filled, and when wooden barrels or buckets are used their interior should be charred. Use fresh, clean water, as free as possible of organic matter, and when the vessels are filled, sprinkle the surface of the water with crushed charcoal and protect the water from contamination.

Saving by Use of Feed-Water Heater—What saving of heat is obtained by using exhaust steam to heat feed water from 55 deg. F. to 204 deg. F., the boiler pressure being 100 lb. per sq.in.?

A. W.

The gain per pound of feed water would be 204 — 55 = 149 B.t.u. The heat required per pound of steam raised from 32 deg. F. to 100 lb. gage pressure (shown by steam tables) is 1188.8, hence with feed water at 55 deg. F., i.e.,

55 — 32 = 23 deg. F. above 32 deg. F.,

each pound of water, for conversion into steam at 100 lb. boiler pressure, would require 1188.8 — 23 = 1165.8 B.t.u., therefore the saving by use of the feed-water heater would be

$$\frac{149}{1165.8} \times 100 = 12.78 \text{ per cent.}$$

One Safety Valve Discharging through Another—When two safety valves are each set to blow off for 200 lb. per sq.in. gage pressure, the first valve discharging through the second valve, why is it that a pressure of 400 lb. per sq.in. gage pressure would be required on the underside of the first valve for discharge to take place through the second valve?

W. J. K.

For either valve to discharge, the pressure on its under side would have to be 200 lb. per sq.in. greater than the pressure into which it discharges, and as for discharge to take place through the second valve, the pressure connecting the discharge side of the first valve with the underside of the second valve would have to be 200 lb. per sq.in. above atmospheric pressure, then for both valves to operate at the same time, the pressure on the underside of the first valve would have to be 200 lb. per sq.in. + 200 lb. per sq.in. above atmospheric pressure, i.e., 400 lb. above atmospheric pressure.

Delivery of Pump—At 40 r.p.m. and allowing 7 per cent. slippage, how many gallons of water would be delivered per minute by a duplex pump having water pistons 8 in. in diameter by 10-in. stroke and piston rods 1¾ in. in diameter?

The area of an 8-in. diameter piston being 50.265 sq.in. and the cross-sectional area of a 1¾-in. diameter piston rod being 2.405 sq.in., then, for each revolution of the pump, there would be two piston displacements due to the full area of the piston with 10-in. stroke, or,

$2 \times 50.265 \times 10 = 1005.3$ cu.in. of piston displacement

and also two piston displacements due to the area of the piston, minus the cross-sectional area of the piston rod, with 10-in. stroke or

$$2 \times (50.256 - 2.405) \times 10 = 957.2 \text{ cu.in.}$$

of piston displacement.

Therefore the total piston displacement per revolution would be:

$$1005.3 + 957.2 = 1962.5 \text{ cu.in.}$$

and for 40 r.p.m. and 7 per cent. slippage the delivery would be

$$93 \text{ per cent. of } \frac{1962.5 \times 40}{231} = 316 \text{ gal. per min.}$$

Horsepower of Vertical Boiler—What would be the horsepower size of a vertical boiler containing forty 1½-in. tubes 4½ ft. long and having a firebox 28 in. in diameter by 22 in. high?

E. B.

The horsepower size of a boiler is based upon the number of square feet of heating surface. In a vertical boiler this consists of the heating surface in the sides and tube sheet of the firebox, plus that in the tubes. The firebox being 28 in. in diameter its circumference would be

$$28 \times 3.1416 = 87.965 \text{ in.}$$

and being 22 in. high, then the area of the sides of the firebox would be

$$87.965 \times 22 = 1935.23 \text{ sq.in.}$$

The gross area of the firebox tube sheet would be

$$28 \times 28 \times 0.7854 = 615.75 \text{ sq.in.}$$

For each 1½-in. tube (the external diameter of a 1½-in. tube being 1½ in.), the area would be

$$1\frac{1}{2} \times 1\frac{1}{2} \times 0.7854 = 1.767 \text{ sq.in.,}$$

and there being 40 tubes, the total cros-sectional area of the tubes would be

$$1.767 \times 40 = 70.68 \text{ sq.in.;}$$

therefore, the net heating surface of the tube sheet would be

$$615.75 - 70.68 = 545.07 \text{ sq.in.}$$

The internal diameter of each tube being 1.31 in., its circumference would be

$$1.31 \times 3.1416 = 4.115 \text{ in.,}$$

and the length of the tubes being 4½ ft., or 54 in., the area of each tube would be

$$4.115 \times 54 = 222.21 \text{ sq.in.}$$

and the area of the 40 tubes would be

$$222.21 \times 40 = 8888.4 \text{ sq.in.}$$

Hence as

The area of the sides of the firebox	=	1,935.23 sq.in.
The net area of the tube sheet	=	545.07 sq.in.
The areas of all the tubes	=	8,888.4 sq.in.
Total area	=	11,368.7 sq.in.

Reduced to square feet, this would be

$$11{,}368.7 \div 144 = 78.9 \text{ sq.ft.}$$

and allowing 10 sq.ft. per horsepower the horsepower of the boiler would be

$$\tfrac{1}{10} \text{ of } 78.9 = 7.89 \text{ hp.}$$

Engineers' Study Course

The Slide Rule--III

LAST LESSON'S ANSWERS

6. The problem as given cannot be solved at one setting. If the first term in the numerator and the denominator are interchanged, making the problem

$$\frac{0.492 \times 1.29}{33.4}$$

it can be solved at one setting as follows:

Remembering that the decimal points are not to concern us until the end of the problem, set the hair line over 492 on the D-scale. Do this by first moving the runner to 4. The number shows that we are to go $\frac{9}{10}$ of the distance to 5, so keep on moving the line, passing over the main divisions 41, 42, 43, 44, the longest line shown at 45, then on over 46, 47, 48 and, finally, stop at 49, within one more large space of 5. Now, to get $\frac{2}{10}$ of the remaining distance to 5, notice that there are only two small divisions, so each must represent $\frac{5}{10}$, hence $\frac{2}{10}$ will be $^2/_5$ of one of the smallest spaces at this part of the rule and must be guessed at. Leaving the runner at this point, move the slide until 334 on the C-scale comes under the hair line. First move the slide until 3 is under the hair line. Then counting the bigger divisions move the slide to the left until $\frac{3}{10}$ of the distance to 4 is covered, that is, passing 31, 32 and stopping at 33. The slide must go still further to the left, but not so far that 34 will be under the hair line. It is to go only $\frac{4}{10}$ of the distance between 33 and 34. As this distance is divided into five spaces, each space represents $\frac{4}{10}$, and the slide is to be moved still farther until the second short line on the C-scale after 33 is under the hair line. This is the only setting of the slide. The answer will be found under 129 on the C-scale. Move the hair line first to the second marked or numbered division on the C-scale from the left-hand "1." This will be 12. (On some rules it is marked "1.2"; on others simply "2.") There are ten divisions between 12 and 13, so that nine of them are to be passed over in setting the hair line at 129. In the proper position the hair line will be just one of the smallest spaces to the left of 13 on the C-scale.

The answer on the D-scale is closely 19, as near as it can be read and well within the limit of the accuracy of the rule. Now to locate the decimal point. Inspection of the numerator shows it to be approximately 0.5 and 33 will not go into it until it is multiplied by 100 or the decimal point moved two places to the right. The first figure in the answer will, therefore, come in the second place after the decimal point, or 0.019 is the answer.

7. Following the rule "set the first on the second under the third find the fourth"; first place the hair line over 408 on the D-scale. Slide it at once to 4. It must not go one of the larger divisions farther, as that would be 41, and 408 is $\frac{8}{10}$ of the distance between 4 (or 40) and 41. The smaller divisions are $\frac{5}{10}$ of the next larger, so the hair line is to be moved one whole small division to the right from 4 and then over $^3/_5$ of the next space to estimate 408. Leaving the runner here, move the slide until 61 on the C-scale is under the line (61 is one of the larger, or two of the smallest spaces to the right of 6). Now, leaving the slide set, move the runner to 32 on the C-scale (32 is two of the larger, or ten of the smallest spaces to the right of 3). Under the hair line on the D-scale is the answer which is seen to be something between 2 and 3, and as it comes in the second large division, is between 21 and 22. It is practically on the line between the second and third smallest divisions. As each of these smallest divisions represents $\frac{2}{10}$, the answer is $\frac{4}{10}$ more than 21, or 214, and it can plainly be seen that it is a whole number, the decimal going after the 4.

8. Let us examine the old familiar horsepower formula:

$$hp. = \frac{PLAN}{33{,}000}$$

Evidently increasing the mean effective pressure, or the length of stroke or the area of the cylinder or the number of strokes per minute would increase the value of the fraction and make the horsepower larger. It is stated that the pressure remains the same; the length of the stroke and area of the cylinder must also. The only quantity that changes is the strokes per minute, and just as this changes the horsepower changes, so the problem may be solved as a simple proportion, thus,

$$160 : 45 : : 200 : x$$

Set the hair line on 45 on scale *D* (midway between "4" and "5"). Move the slide to the right until 16 on scale *C* is under the line (16 is the end of the sixth large division between "1" and "2"). The answer is on *D* under "2" on *C*. It is found to be between "5" and "6" and between 56 and 57 and about ½ of the smallest division after 56. Each of these smallest divisions being $\frac{5}{10}$, the answer is ¼ more than 56, or 5625, and the decimal point, as may be seen by inspection, belongs after the 6, making the answer 56.25 hp.

9. The number 42,200 has an odd number of integers, therefore the left-hand A-scale is to be used. Set the hair line on 422 on the A-scale. (First set the line on "4." Then move it two large or four of the smallest divisions to the right. This is 42. Then as each of these smallest divisions is $\frac{5}{10}$, the line is to be moved $^2/_5$ of one of these divisions farther to the right. This distance must be estimated.) Under the hair line on scale *D* is the square root, which is more than 2 and less than 21; it is a little over 205 (each of the smallest divisions being $\frac{2}{10}$). Evidently the hair line divides the smallest division within which it falls into about $\frac{6}{10}$ and $\frac{4}{10}$, and as the division represents 2, $\frac{6}{10}$ of $2 = {}^{12}/_{10}$ of 1. Hence, as close as can be estimated, the answer is 2052 and, pointing off the original number by "twos" of places as 4'22'00, there will be three whole-number places in the square root, making it 205.2. (More exactly the answer is 205.4264.)

10. Invert the slide in the rule so that the numbers on

the slide are upside down with respect to those on the rule. Point the number off in units of three places, as 42'200. The answer is to have two whole-number places and the first figure is to be the cube root of the largest number less than 42. Evidently then it will be 3, for $3 \times 3 \times 3 = 27$, while $4 \times 4 \times 4 = 64$. This shows around what point on the rule the answer is to be looked for, so that there need be no danger of the confusion mentioned in the last lesson. Set 422 on the right-hand A-scale just as it was set in the last problem on the left-hand A-scale. (On some rules the "4" is marked "40" on the right-hand scale.) Bring the right-hand "1" of the C-scale to this point. Now move the runner until the hair line covers the same number on the D-scale and the upside down B-scale. When the line is over the "3" of the B-scale, it is over 375 of the D-scale, so it should go farther to the left. At 31 on *B*, 369 is covered on *D*. At 32 on *B*, 357 on *D*. At 34 on *B*, 352 on *D*. At 345 on *B*, 35 on *D*. Evidently 3485 is as close as the cube root can be estimated, and it will have only two places; therefore, 34.85 is the cube root of 42,200. (More exactly the cube root is 34.8154.)

The Slide Rule Continued

Another useful application of the rule with the slide inverted is in the dividing of a given number by any number at one setting. This is evident from the fact that the inverted slide gives reciprocals, for, in the normal use of the rule, the product of a given number and any other number is obtained at a single setting. Suppose, as in the compiling of a table, it is desired to divide a certain number by each number in a column of numbers.

For instance, a tank holds 12,000 gal., and it is desired to know how many minutes it will take to discharge it at various rates of discharge.

Set the left-hand "1" of the inverted C-scale on 12 of the D-scale. Then under any number on the C-scale (inverted) will be found on the D-scale the quotient of 12,000 divided by the C-scale number.

For instance, if the rate of discharge is 40 gal. a min., the time to discharge 12,000 is 300 min., and so a table could be constructed with one setting of the slide by simply moving the runner.

Gal. per Min.	Discharging Time in Min.
40	300
80	150
120	100
160	75
200	60
240	50
280	42.8
320	37.5

Often it is hard to make an exact setting on the rule where much of the number has to be estimated. If a factor of that kind is to be used frequently, so as to warrant it, an equivalent ratio may be found that is more readily set. The number π (3.14159) is so often used that some rules have a line for that number, but if they have not, if 226 of the C-scale is set on 710 of the D-scale, under the left-hand "1" of the C-scale will be π (3.14159) on the D-scale. At this setting of the rule the circumference of a circle of any given diameter may be found on the D-scale under the corresponding diameter on the C-scale.

A number of these equivalent ratios for conversion factors, such as are usually given on the backs of slide rules, are herewith tabulated. Remembering the proportion rule, "On the first set the second, &c.," any of these conversion ratios may be used.

$$\frac{226}{710} = \frac{\textit{diameter of circle}}{\textit{circumference of circle}}$$

$$\frac{40}{9} = \frac{\textit{circumference of circle}}{\textit{side of inscribed square}}$$

$$\frac{39}{11} = \frac{\textit{circumference of circle}}{\textit{side of equal square}}$$

$$\frac{70}{99} = \frac{\textit{side of square}}{\textit{diagonal of square}}$$

$$\frac{11}{14} = \frac{\textit{square inches}}{\textit{circular inches}}$$

$$\frac{300}{191} = \frac{\textit{area of circle}}{\textit{area of inscribed square}}$$

$$\frac{5}{127} = \frac{\textit{inches}}{\textit{millimeters}}$$

$$\frac{292}{89} = \frac{\textit{feet}}{\textit{meters}}$$

$$\frac{35}{32} = \frac{\textit{yards}}{\textit{meters}}$$

$$\frac{87}{140} = \frac{\textit{miles}}{\textit{kilometers}}$$

$$\frac{31}{200} = \frac{\textit{square inches}}{\textit{square centimeters}}$$

$$\frac{140}{13} = \frac{\textit{square feet}}{\textit{square meters}}$$

$$\frac{61}{51} = \frac{\textit{square yards}}{\textit{square meters}}$$

$$\frac{36}{590} = \frac{\textit{cubic inches}}{\textit{cubic centimeters}}$$

$$\frac{106}{3} = \frac{\textit{cubic feet}}{\textit{cubic meters}}$$

$$\frac{6700}{29} = \frac{\textit{cubic inches}}{\textit{U.S. gallons}}$$

$$\frac{234}{1750} = \frac{\textit{cubic feet}}{\textit{U.S. gallons}}$$

$$\frac{3}{85} = \frac{\textit{cubic feet}}{\textit{liters}}$$

$$\frac{280}{127} = \frac{\textit{pounds}}{\textit{kilograms}}$$

$$\frac{62}{63{,}000} = \frac{\textit{tons}}{\textit{kilograms}}$$

$$\frac{128}{9} = \frac{\textit{pounds per square inch}}{\textit{kilograms per square centimeter}}$$

$$\frac{13}{30} = \frac{\textit{pounds per square inch}}{\textit{feet of water}}$$

$$\frac{970}{66} = \frac{\textit{pounds per square inch}}{\textit{atmospheres}}$$

$$\frac{174}{850} = \frac{\textit{pounds per square foot}}{\textit{kilograms per square meter}}$$

$$\frac{17}{1060} = \frac{\textit{cubic feet of water}}{\textit{pounds of water}}$$

$$\frac{51}{1440} = \frac{\textit{cubic feet of water}}{\textit{kilograms of water}}$$

$$\frac{340}{47} = \frac{\textit{foot-pounds}}{\textit{kilogram-meters}}$$

The manuals that deal with the slide rule usually give still more of these factors and the reader can readily figure out his own for any special problem he may have.

Tests of Four-Pass Boiler with Illinois Coal

The second of the informal dinner discussions of the Chicago Section of the American Society of Mechanical Engineers was held in the Crystal Room of the Hotel Sherman, Chicago, Ill., on the evening of Jan. 28. The meeting was attended by 140 members and guests and was opened by the chairman of the local committee, Paul P. Bird. The paper of the evening, by Bryant Bannister, dealt with a series of boiler tests with Illinois coal and was in substance as follows:

In April of 1913 a new boiler house was completed at the works of National Tube Co., at Kewanee, Ill., and a series of tests, ranging in length from 4 to 24 hr., and with loads varying from 75.6 to 205.2 per cent. of rating, were conducted.

In order to eliminate error in estimating the amount of coal on the grate it was thought best to conduct a test of much longer duration. The data obtained from the first eleven tests, therefore, are given out at this time only as corroborated by the results obtained in a 72-hr. test completed Oct. 30.

The complete boiler plant consists of four Edge Moor water-tube boilers, each set as a unit, having 20-ft. tubes, and baffles arranged to give four passes for the gases, with the stack outlet at the bottom of the fourth pass. Each has 6132 sq.ft. of heating surface and 1200 sq.ft. of superheating surface, Foster superheaters being installed. Each boiler is set with the bottom of the front header 8.67 ft. above the level of the dumping plate of the stoker, thus giving the large combustion chamber so essential to the thorough combustion of highly volatile coals. The firing is done by a seven-retort Taylor stoker equipped with an air extension grate. Each stoker has its own fan and engine.

Much was done to make each boiler setting tight and as free from radiation losses as possible. The setting was first coated with a thick asbestos paint, and then covered with 1½ in. of 85 per cent magnesia, and finally with muslin and again painted to insure against air leakage. The headers were also covered, where exposed, with this same magnesia compound, and the whole setting top was covered with a three-inch layer of firebrick and cement, and then with the magnesia covering. At no time during the tests was the setting more than warm, even at the highest loads.

Gland leakage on the feed pump was weighed and accounted for and no blow-downs were made during any of the tests. The safety valves on the test boiler were set

FIG. 1. RELATION BETWEEN RADIATION AND MISCELLANEOUS LOSSES AND LOAD

several pounds above those on the remaining boilers, but at the higher rates of evaporation pop-offs were unavoidable; these were carefully timed and accounted for.

Flue gases were drawn from the bottom of the fourth pass and analyzed by an Orsat apparatus. Since each boiler unit has its own stack it was further possible to properly regulate the air supply to the stoker by observing the smoke condition. As shown by the data, the furnace draft was maintained as low as possible.

Referring to the first eleven tests, made earlier in the year, the apparent disparity between efficiencies at similar loads is noticeable. There was considerable range in the moisture content of the coal samples, which was due largely to rainfall after the first three tests, much of the coal being exposed. Also, neither the quality of the flue gases nor the percentage of combustible in the ash forms any definite curve when plotted against the load. The heat balance gave little information other than that the tests were too short to be reliable if taken individually. Therefore, a second heat balance was created, based upon the average of those factors not influenced by the rate of firing, such as moisture, CO in the flue gas, and combustible in the ash. The dry flue gas loss was changed to correspond to the gas temperatures obtained from Fig. 2; and the whole was balanced with the radiation loss obtained from Fig. 1. The curve in Fig. 1 was assumed after careful comparison of the Kewanee boiler settings with those of the large units in the Detroit Edison plant. The setting comparisons were made upon a basis of exposed areas, temperature of exposed areas above boiler room, and character of setting wall, together with the relative rated capacities of the units. In

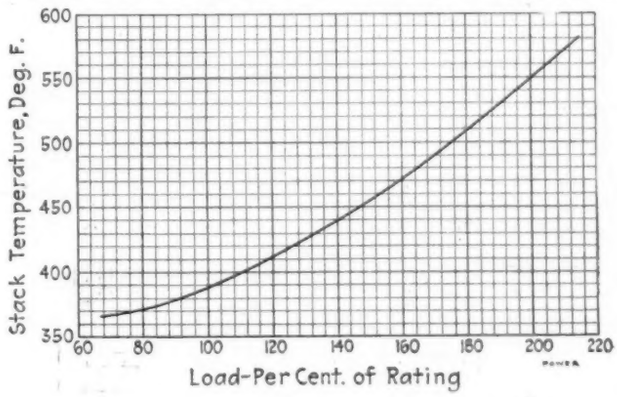


FIG. 2. STACK TEMPERATURE VS. LOAD

effect it is thought that this created curve represents approximately what would be accomplished by tests of indefinite length, with coal of the average moisture, hydrogen, etc., as obtained during these tests, and with the same combustion as shown by the average of the gas and ash analyses for these tests.

Referring to the actual heat balance for test number twelve, the 72-hr. test, it will be observed that the residue

TABLE I. HEAT BALANCE, EVAPORATIVE TEST NO. 12

	B.t.u.	Per Cent.
Heat absorbed by boiler	8980	80.95
Loss due to evaporation of moisture in coal	231	2.08
Loss due to heat carried away by steam formed by burning of hydrogen	494	4.45
Loss due to heat carried away in dry flue gases	855	7.71
Loss due to carbon monoxide	35	0.31
Loss due to combustible in ash and refuse	223	2.01
Loss due to radiation and unaccounted for	276	2.49
Calorific value of 1 lb. of dry coal	11,094	
Total		100.00

for radiation and miscellaneous losses falls upon the curve in Fig. 1.

DISCUSSION

H. P. BRYDON thought that the Kewanee Works had shown courage in installing a type of stoker which had made its chief success with the higher grade coals of the East, and expressed curiosity as to what part the stoker played in attaining the high efficiencies.

He also thought that the steam consumed by the stoker engines and by the soot blowers should be deducted from the total, and further expressed the opinion that the four-pass design and the heavy lagging were largely instrumental in attaining the high efficiency.

R. H. KUSS submitted the following written discussion:

Even without correction or adjustment the efficiency results are exceedingly good. Certain critical items of the series of tests can be picked out to advantage. One of these is the low gas exit temperatures which indicates high heat absorption. This is particularly accounted for by the baffling.

During the 72-hr. test (No. 12) temperature readings were taken regularly at points above and below the fourth pass. The averages of the calibrated readings showed a temperature difference of 67.4 deg. F., which indicates a heat absorption of a little above 2 per cent. of the heat value of the fuel.

If it is conceded that the last pass is responsible for this amount of heat saving, an appreciable amount above that usually encountered with standard three-cross pass boilers is still to be accounted for. The conclusion is inevitable that the baffling of the first three passes contributes in no small degree to the general high efficiency results, or a temperature as low as 470 deg. F. would not have been encountered at the end of the third pass, even crediting the setting with special provisions against radiation and air leakage. It is clear that for good absorption results, 18-ft. tubes are not necessary for three-pass boilers, provided the baffling is such as to employ the heating surface to advantage.

It is obvious that the tube proportions could not have been duplicated without the inclined first flame plate, and this test series, combined with the close scrutiny of many other four-pass installations, leads to the conclusion that it is not possible to create a successful four-pass setting with all of the baffling at right angles to the tubes, even when using 20-ft. tubes, unless the setting is to sacrifice a large part of its elasticity in capacity possibilities. If this conclusion is correct, then security must be had against baffle leakage and general baffle deterioration. The use of tile resting against metal supports in an inclined position is not successful in the construction of the inclined flame plates. Recourse is best taken to building the first flame plate by the older, more costly and perhaps less attractive, method of "grouting" in position baffles made up of plastic refractory material reinforced with metal as was done at Kewanee. That this method made possible the location and protection of soot blower pipes is worthy of note, although the main reason for the selection of this construction came from a desire to create a tight baffle in an inclined position.

Aside from the greater economy in the absorption of heat due to four passes in place of three passes, several other important advantages may be mentioned; these are:

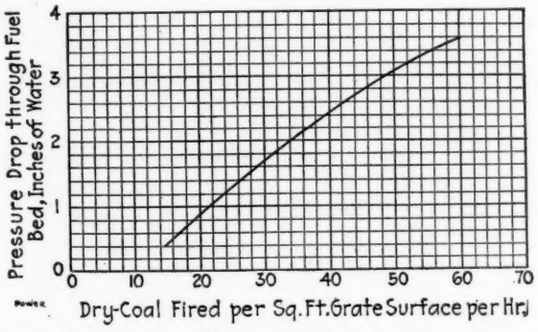


FIG. 3. EFFECT OF RATE OF FIRING ON PRESSURE DROP THROUGH FUEL BED

1. The breeching is below the boiler; consequently the boiler-room roof may be lower than for a three-pass setting. The breeching is out of the way of piping, and heated air surrounding the breeching due to radiation can be carried direct to the furnace beneath the boiler-room floor, making the boiler-room cooler.

2. The cleaning of soot from the tubes may be done more effectively because the gas passages are less in width.

3. Where the plant arrangement permits, the space between the normal boiler-room floor and the rear boiler header can be used for breeching construction. Almost the entire setting behind the furnace bridgewall is of little use in the three-pass setting; the brick cost, air infiltration and radiation losses of these walls can be largely done away with by constructing the breeching immediately behind the furnace bridgewall. By the same design there is created a boiler-room floor level behind and between the settings, from which soot blowing, washing, blowing-down, etc., can be accomplished without the use of platforms or ladders. The disadvantage of two elevations disappears if the engine-room floor is of a higher elevation than the boiler room, and provided that the engine room is located behind the boiler room. The setting cost plus the breeching cost is less than for a normal three-pass setting plus a breeching.

A. BEMENT wished to know whether the total or the available hydrogen contained in the coal was considered when calculating the loss due to the water formed by this

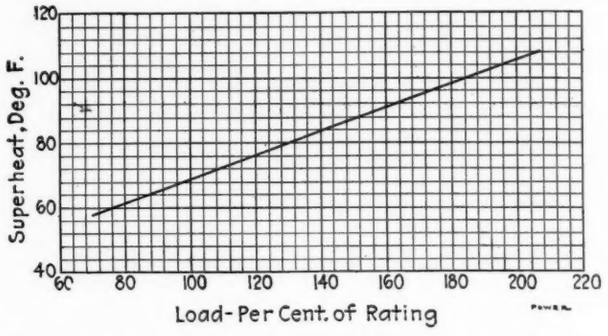


FIG. 4. RELATION BETWEEN SUPERHEAT AND LOAD

constituent in the products of production. He also asked how the fires were cleaned and how often, and commented on the tendency to get low heat measurements with low capacities and high measurements with high capacities, due to the changing of the center of gas travel with different velocities and volumes. He believed the present tendency favored the four-pass arrangement and stated that he had even gone to the extent of designing a five-pass boiler with 18-ft. tubes, although perhaps in such a design a 20-ft. tube would be more desirable.

JOSEPH HARRINGTON submitted a written discussion in part as follows:

A perfect furnace would completely burn all the combustible in the coal fired with just the theoretical amount of air. With no losses due to combustible in the ash, CO in the furnace gases or excess air, the furnace efficiency would be 100 per cent. A perfect furnace and a perfect boiler would not, however, give 100 per cent. combined efficiency; first, because coal is not a perfect fuel, and second because the gases must escape at a temperature at least equal to the steam temperature, which is always higher than the surrounding air.

The magnitude of these necessary losses depends upon the amount of moisture and hydrogen in the fuel, the boiler pressure, and the temperature of the air in the boiler room and until they are known, and a proper allowance for their effect is made, a test cannot be scientifically analyzed or two tests compared. For instance, a test at 78 per cent. combined efficiency may be a better performance of both the boiler and furnace than another at 80 per cent. under different conditions, because the necessary losses might be more than enough to account for this difference.

After deducting the necessary losses per pound of coal as fired from the B.t.u. as fired, there remains an amount of heat all of which a perfect boiler and furnace could utilize. The ratio of the amount of heat theoretically avail-

TABLE 2. TESTS OF EDGE MOOR WATER-TUBE, FOUR-PASS BOILER

	Test No. 1	Test No. 2	Test No. 3	Test No. 4	Test No. 5	Test No. 6	Test No. 7	Test No. 8	Test No. 9	Test No. 10	Test No. 11	Test No. 12
Duration, hr	8	8	8	8	24	8	8	8	8	4	8	72
Steam pressure, lb	112.1	115.1	112.3	118.5	116.0	113.7	116.0	111.9	115.8	122.9	112.4	117.6
Temperature of feed water, deg. F	193.6	189.6	189.4	185.3	183.9	187.3	187.1	189.4	189.9	184.0	192.1	194.9
Temperature of gases leaving boiler	404	434.3	428.2	479.2	450.1	421.2	418.8	359.0	459.1	510.3	376.1	412.0
Draft in furnace	0.042	0.043	0.023	0.027	0.014	0.028	0.025	0.031	0.029	0.056	0.012	0.011
Blast pressure under grate	1.69	2.07	1.86	2.48	1.80	1.17	1.45	0.60	1.96	3.31	0.63	1.95
Deg. of superheat	60.5	82.5	83.5	80.8	91.2	82.3	77.7	61.1	84.7	105.3	59.2	77.9
Moisture in coal per cent	12.81	11.63	11.41	13.10	14.08	13.86	15.63	15.51	13.63	15.76	15.77	16.15
Percentage of ash and refuse in dry coal	24.90	24.57	24.38	22.29	24.48	22.36	22.12	21.49	23.85	19.26	21.46	20.98
Dry coal consumed per sq.ft. of grate surface per hr	30.2	37.4	34.6	44.6	32.5	24.2	28.7	17.3	39.3	56.6	18.8	28.5
Equivalent evaporation per hr. from and at 212° per sq.ft. of water heating surface	3.37	4.05	3.88	4.64	3.69	2.81	3.46	2.19	4.35	5.92	2.18	3.28
Horsepower developed	715.3	860.8	824.6	984.4	784.1	596.8	734.9	466.2	922.2	1258.4	463.8	695.6
Per cent. of rated capacity developed	116.7	140.4	134.5	160.5	127.9	97.3	119.8	76.0	150.4	205.2	75.6	113.4
Water fed per lb. of coal fired	7.13	6.94	7.2	6.51	7.00	7.21	7.35	7.84	6.91	6.27	7.19	7.022
Equivalent evaporation per lb. of dry coal	8.97	8.73	9.04	8.37	9.15	9.33	9.70	10.21	8.90	8.42	9.36	9.254
Equivalent evaporation per lb. of combustible burned	12.19	11.82	12.19	10.97	12.11	12.02	12.45	13.01	11.69	10.43	11.92	11.711
Calorific value of 1 lb. of dry coal, B.t.u	11,325	11,318	11,211	11,290	11,048	11,282	11,335	11,488	11,303	11,844	11,598	11,094
Calorific value of 1 lb. of combustible, B.t.u	14,454	14,398	14,325	14,032	14,123	14,175	14,088	14,227	14,209	14,296	14,331	13,773
Efficiency of boiler furnace and grate	76.87	74.92	78.27	71.98	80.38	80.27	83.05	86.32	76.47	69.02	78.36	80.95

able to that contained in a pound of coal as fired is the "ideal efficiency" and should form the basis for all analyses of results.

The ideal efficiency for the Kewanee test is about 89 per cent. The combined efficiency of 80.95 per cent. is, therefore, about 91 per cent. of that theoretically possible and 91 per cent. is, therefore, the real measure of the performance or actual efficiency of the unit. Fig. 1 has been assumed from a comparison of the Kewanee setting with the Detroit Edison installation, but in this comparison the most important feature has been overlooked, namely, the relative size of the combustion chambers, the Detroit boilers having furnaces of much larger volume per pound of combustible burned.

A definite time is required for the complete mixing of the oxygen with the combustible and if the rate of combustion is too high, the mixing and burning are not completed before the gases reach the cooling surface of the boiler and are cooled below the ignition point. A loss then results which cannot be accounted for and is not necessarily detected in the gas analysis. In reality this is a furnace loss, but in the absence of an accurate means of determination, it is of necessity included in the miscellaneous losses.

Volume alone is not the controlling factor in the value of a furnace. Its cross-section proportions are of primary importance, as a sufficient distance from the fuel bed to the tube line is essential for proper combustion. As long as the furnace efficiency remains constant, the principal factor tending to reduce the combined efficiency is the flue gas temperature, and the capacity-efficiency curve will approximate a straight line with a slight downward slope in the direction of increasing capacity.

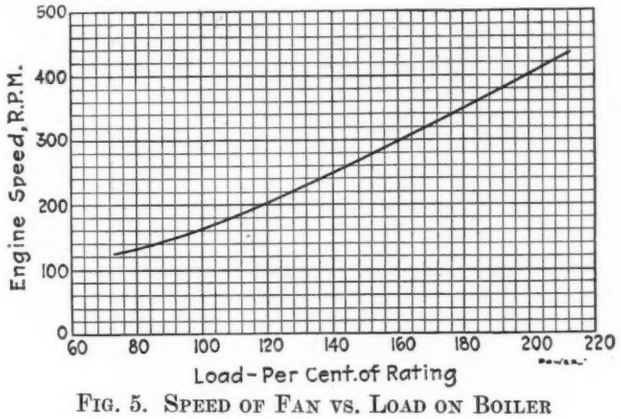


FIG. 5. SPEED OF FAN VS. LOAD ON BOILER

The Kewanee tests differ from the Detroit tests in that at Kewanee the most efficient furnace capacity was exceeded above 120 per cent. of rating, whereas at Detroit the limit of efficient furnace capacity was not reached at 200 per cent. The most noticeable point of excellence at Detroit was the large combustion chamber, whereas at Kewanee it was the low flue-gas temperature.

The first eleven tests were of too short duration to insure accurate results. Mr. Bannister recognized this and ran test No. 12 for 72 hr. to eliminate the errors due to starting and stopping. This test checks very closely with the average of the shorter tests.

The number of boilers in service should be such that each operates at or near its point of maximum efficiency, if the load on the entire station is practically constant; but as this is seldom the case, a certain range of unit capacity is necessary. When the point is reached where further decrease in unit capacity causes a decrease in efficiency, which will more than offset the loss of banking one boiler over the period of low load, banking should begin. With increasing load, additional boilers should be put on as soon as the load becomes large enough to permit their efficient operation. This affords protection against an unexpected or early increase in load and also has every boiler thoroughly warmed up and all fires in good condition before the peak load comes on. For short peaks it will usually be found most economical to drive boilers to their maximum capacity, even if this is above the limit of efficient operation.

A high efficiency test like the one under discussion, does not guarantee low steam cost in yearly operation. Of greater importance is the maintenance of those conditions that contributed to the high efficiency. The apparatus here described could be so operated as to offset its inherent efficiency, so that the annual steam cost is really a factor, not only of the apparatus efficiency, but of the efficiency of the boiler room organization.

F. C. GASCHE believed the success of Mr. Bannister, in using a coal containing approximately 20 per cent. ash and 15 per cent. moisture with a boiler and furnace efficiency exceeding 80 per cent. to be without precedent in steam engineering in this region. He mentioned that if the accumulating deliveries of fuel and water are recorded graphically with possibly hourly corrections for water levels, etc., there can be shown two curves for which an average inclination can be assigned. About ten years ago he had succeeded in obtaining 78 per cent. overall efficiency with dust fuel and a special type of furnace in connection with a water-tube boiler. Owing to difficulties in maintaining the furnace construction the process did not, at that time, develop into a commercial success but the investigation indicated that under proper furnace conditions, it was possible to burn Illinois coal with its encumbrance of 18 per cent. ash and about 14 per cent. moisture with an excess air supply scarcely exceeding 12 per cent. of the theoretical requirements.

J. C. BANNISTER, manager of the Kewanee Works, stated that the problem was to use a cheap available coal of poor quality without too much hand labor. The load conditions at the plant are favorable and a maximum load of 150 per cent. of rating is all that is required. He gave the following operating figures for the months of October, November and December, where conditions were unfavorable in that the plant was working irregularly. The average coal consumed per boiler horsepower-hour was for October, 4.53 lb., November, 4.70 lb. and December, 4.49 lb. The overall efficiency as calculated from the coal weights and water fed were for October, 77.7 per cent., November, 76.3 per cent., December, 78.5 per cent. The average load per boiler was for October, 721.8 hp., November, 565.4 hp., December, 656.8 hp.

In closing Mr. Bryant Bannister stated that the capacity test had not extended beyond four hours because the fan engine was not in good condition and it was deemed dangerous to operate it at the high speed (over 400 r.p.m.) for a much longer period. He stated that no furnace trouble was had during the high rate of driving. The clinkering took the form of a slagging process and the ash and refuse seemed to flow to the pit when the dumping plates were lowered. He did not know what the steam consumption of the soot blowers was, but did not believe it amounted to much. In answer to Mr. Bement he stated that the total hydrogen content was employed in calculating the losses due to the formation of water in the flue gases.

NEW PUBLICATIONS

THE MECHANICAL WORLD POCKET DIARY AND YEAR BOOK FOR 1914. Three hundred and eighty-eight 4x6-in. pages; 82 illustrations; indexed. Price, 25 cents. Norman Remington & Co., Baltimore, Md.

The 1914 edition of this well known pocket book is in keeping with the excellence and low cost of those of the years before. The matter has been increased by rewriting the section on steam turbines, adding a new section on the use of the miller and gear cutter, and fresh material on grinding. New tables include the dimensions of keys, hydraulic packing, copper expansion joints, the weight of octagonal iron and steel, weights of finished nuts, setscrews, and the like.

HANDBOOK OF ELECTRICAL METHODS. Published by McGraw-Hill Book Co., New York. Size 6x9 in.; 285 pages, illustrated. Price, $3 net.

Realizing that much useful material in a technical paper is discarded through failure of the reader to keep files or clippings, the publishers have selected a large number of short practical items from the issues of the "Electrical World" for the past three or four years. These have been classified under headings such as line construction, meters, operation of circuits, switchboards, lighting, signal bells, transformers, motors, generators, etc., and compiled in book form. The great variety of subjects presented and the concise treatment make the book interesting as well as useful to the operating man.

The Effects of Ice on Stream Flow—The design, installation, and operation of any plant that depends for its success upon flowing water demands a knowledge of the total flow of the stream and its variation throughout the year. The United States Geological Survey has been compiling for years stream-flow records for many streams in the United States and the methods of collecting such records for open-water periods have been standardized, but during the winter the presence of ice affects the flow so much that the laws of flow pertaining to open channels are not entirely applicable, and no standard methods for collecting and inter-

preting the data at that season have been recognized. In many localities ice persists in the streams for periods ranging from a few days to several months, and although the conditions resulting from ice are most pronounced in northern regions they are prevalent over wide areas, especially at high altitudes.

Recent studies made by the Geological Survey have added much information in regard to the factors influencing stream flow when ice is present, and with a view to standardizing, so far as practicable, the methods for ascertaining winter flow, Water-Supply Paper 337, entitled "The Effects of Ice on Stream Flow," by William Glenn Hoyt, has been published and is available for free distribution. This paper discusses the factors that influence the run-off during the periods of low temperature, the varieties of ice and their effect on the applicability of the laws of open-channel flow, and the collection and interpretation of necessary data.

A copy of the report may be obtained free on application to the Director of the Geological Survey, Washington, D. C.

SOCIETY NOTES

The annual banquet of the Engineers' Society of Western Pennsylvania was held at the Hotel Schenley, Pittsburgh, Penn., the night of Feb. 6, with 725 at the tables. John Mapes Dodge, editor of "St. Nicholas Magazine," acted as toastmaster. Major-General Leonard S. Wood, chief of staff, United States Army, was to have been the principal speaker, but was kept in Washington by important army measures coming up in Congress. Rear-Admiral S. A. Staunton, U. S. N.; President Alfred H. Smith, of the New York Central R.R., and Dr. S. A. Bolles, president of Haverford College, were among the speakers. Admiral Staunton devoted his talk exclusively to the development of the navy from the days of the old wooden type up to the contemporary mass of great scientific machinery. President Smith paid tribute to the members of the society, praising their work in the development of the railroads of the world and of their activities in all branches of industrial progress. He deprecated the criticism of all railroads because of the sins of the few and said that next to agriculture the railroad had done more for the development of the nation than any other single factor. He inveighed against government ownership of utilities and said the experience of France in this respect should teach a lesson. Dr. Bolles compared the new currency law with the original national bank enactment. He was doubtful if the several regional banks would be able to obtain as much gold as may be needed to afford relief when desired. The act, he said, was a distinct improvement over the Aldrich system. The ideal banking system he declared would exist only after the Federal Government took complete control of the central bank. Among those at the speakers' table were: Alva C. Dinkey, president of the Carnegie Steel Co.; Congressman James Francis Burke; E. M. Herr, general manager of the Westinghouse Machine Co.; J. M. Dodge, Philadelphia; A. R. Raymer, president, the Engineers' Society; Colonel J. M. Schoonmaker, vice-president, the Pittsburgh & Lake Erie R.R.

PERSONALS

John S. Leese, engineer, has resigned his position with the British Westinghouse Co., Manchester, England, and joined the Osborne-Peacock Co., one of the leading firms of advertisers' agents in that country. Mr. Leese will develop and manage a technical and engineering department, with headquarters in Manchester.

Ernest S. Suffern is president of the Suffern Engineering Corporation which has taken over the business heretofore conducted by Suffern & Son, Singer Building, New York City. The corporation's practice will cover services in connection with organization and management, design, construction and equipment of plants, valuation of properties, and the effective operation of companies.

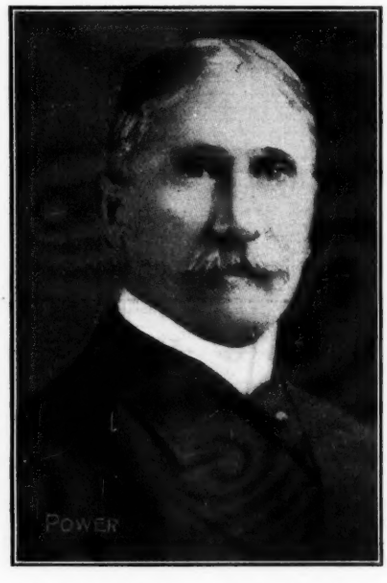
Prof. A. R. Acheson, head of the department of mechanical engineering at Syracuse University, has been appointed consulting engineer for the bureau of gas and electricity, Syracuse, N. Y. He will not sever his connection with the university. Prof. Acheson was selected because of his personal qualifications as an expert on matters handled by the bureau.

OBITUARY

FRANKLIN PHILLIPS

After a brief illness, Franklin Phillips, president of the Hewes & Phillips Iron Works, died suddenly of pneumonia at his residence, Newark, N. J., on Feb. 9. He is survived by a widow, a daughter and a son. Mr. Phillips was born in Newark in the year 1857, and was a son of the late John M. Phillips, founder of the Hewes & Phillips Iron Works, mechanical engineers and builders of the well known Hewes & Phillips Corliss engines. His education was received in the schools of Newark, the Stevens Institute of Technology, and finally Cornell University, where he graduated as a mechanical engineer with the class of 1878. From this time he was active in the Hewes & Phillips Iron Works and for many years was president and general manager.

Mr. Phillips was president of the New Jersey Foundrymen's Association, and a member of the American Society of Mechanical Engineers. He had a broad reputation as a steam and hydraulic engineer and was frequently called into consultation by eminent engineers in relation to large engineering projects. In addition to his business interests he was actively interested in all civic movements that had for their object the prosperity and upbuilding of his city and state, having been a member of the Newark Board of Trade, a member of the Essex Club, and at the time of his death he was



Courtesy "The Newark Evening News."
FRANKLIN PHILLIPS

quartermaster sergeant of the Essex Cavalry Troop, and had been major and inspector of small arms of the New Jersey Second Regiment of infantry.

The funeral services, largely attended by friends, acquaintances and business associates of the deceased, were held at the Phillips homestead, Newark, on Feb. 12.

HENRY BRINTON

Henry Brinton, president of the H. Brinton Co., Philadelphia, died Jan. 30 at his home at Bala after a brief illness. He was born in 1848 at Christiana, Lancaster County, Penn., of a long line of Quaker ancestry descended from William Brinton who came to America in 1684. He received a thorough training as a machinist in the shops of I. Broomell & Sons, now the Christiana Machine Co. Later he spent about two and one-half years with Bement, Miles & Co. Colt's Armory drew Mr. Brinton to Hartford, Conn., where he worked for a time on the Baxter engine. His next work was on the Branson knitting machine at Bellefonte, Penn. The Branson Co. failed and Mr. Brinton went to the Lancaster Watch Co. at Lancaster, Penn., where he obtained experience in fine manufacturing methods. In 1888, Mr. Brinton started manufacturing knitting machines in the partnership of Brinton, Denney & Co. Five years later Mr. Denny sold his interests and the firm name became H. Brinton & Co. Mr. Brinton's wife, a daughter and two sons survive him.